

EXPERIMENTAL TRANSFORMATION OF THE
PERCEPTION OF COLOUR

University of Cape Town

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EXPERIMENTAL TRANSFORMATION
OF THE
PERCEPTION OF COLOUR

Thesis submitted to the Department of Psychology,
University of Cape Town, in partial fulfilment of the
requirements for the Degree of Doctor of Philosophy
in Psychology.

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Rondebosch
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Preface

This thesis presents an argument about the basis of our experience of colour. The argument is conducted by means of an interplay between a set of axioms, deductions from a particular theory (including "thought experiments" which explore the logic of those deductions), and concrete empirical evidence.

The axioms and the theory are those of James G. Taylor. The title of the thesis refers to the general methodology adopted. The term "experimental transformation" carries specific connotations; and the notions from which it is derived, and to which it gives rise, have to be understood in the context of the total argument.

If the argument presented is sound, then certain implications follow which, it is claimed, force us to reconsider many current assumptions about the nature of "colour sensation" and indeed about the very meaning to be ascribed to the term colour. This in turn would have significance for colour science, psychology and epistemology in general.

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The quality which has traditionally differentiated the psychologist from the unspoiled layman is his persistent endeavour to dissect experience.

THOMAS H. HOWELLS

Abstract

The aim of the study has been to outline a general (psychological) approach to colour perception into which variables additional to those relating to photic conditions and photoreceptor processes are incorporated. The argument is conducted by analysing and interpreting certain experiments in which the perception of hue is systematically distorted by various means, contingent on certain critical non-retinal afferents. New computer-controlled experiments are reported in two related fields:- (1) the conditioning of tone-contingent hue responses, and (2) the conditioning of gaze-contingent hue responses. The results in both cases supported the hypotheses (derived from the colour theory of James G. Taylor) that the conditioning of appropriate motor and/or verbal responses to the operating compound afferent input will result in after-effect shifts in hue perception contingent on the relevant alloretinal afferents. Interpretation of the results was carried out with reference to Taylor's axiomatic formulations and it was argued that colour could conveniently be understood in the context of a cybernetic model of organismic functioning. Implications of this view entailed (1) a critique of certain current modes of apprehending colour by philosophers, psychologists, linguists and anthropologists, and (2) a demonstration of how a contrasting framework of reference or paradigm would resolve the anomalies and inconsistencies prevailing in current "colour science".

Summary

In this thesis I have presented evidence and adduced arguments that challenge current notions concerning the experience of colour. These notions prevail not only in psychology and "colour science" but in epistemology generally.

The impetus for this work has come mainly from the axiomatic formulations of James G. Taylor as well as implications which flow from his theory of colour perception. I have not, however, examined that theory as a whole, nor have I related it to the detailed outline of his more general behavioural theory of perception. I have proceeded instead by taking his axioms as my warrant and have then focussed, in some depth, on two specific hypotheses generated by his colour theory.

Both hypotheses are derived from the general notion that retinal afferents are necessary, but not sufficient, to elicit the perception of colour, even in its most basic mode. Both are concerned with transformation of colour perception by the conditioning of hue responses to compound afferent inputs which contain not only photic stimuli, but also certain critical non-retinal stimuli. The first involves the conditioning of tone-contingent hue responses; the second the conditioning of gaze-contingent hue responses. In both cases subjects are required to perform certain tasks, and both require that certain behavioural adaptations should occur. These adaptations require that new motor and/or verbal responses be conditioned to the operating compound

afferent input. The prediction made in each case is that an after-effect change in colour perception (contingent on the critical non-retinal afferent) will occur as a function of such adaptation.

In the first case subjects were placed in a computer-controlled "puzzle environment" where they were subjected to a variety of visual and auditory stimuli. The visual stimuli were 3° red and green lights of differing saturations. The auditory stimuli were dichotically presented; a low tone (260 Hz) in the left ear, and a high tone (390 Hz) in the right ear. Two response-keys were available, but subjects were not told what the task entailed. They were told that the computer was programmed to deliver certain negative and positive feedback signals contingent on their responses. In order to perform the task correctly (i.e. "solve the puzzle") they were obliged to respond to the tone which accompanied a saturated colour and to the hue of an unsaturated colour, irrespective of the accompanying tone. The left key served for a response to the tone of corresponding laterality (in the case of the saturated colours) and for the response of "red" (in the case of the unsaturated colours). The right key served a corresponding function for the other tone and for the response of "green". The contingencies were arranged in such a way that in the process of solving the puzzle and improving their accuracy and speed, the low tone in the left ear preceded the response of pressing the left key (on most occasions), and similarly the high tone in the right ear preceded the response of pressing the right key (on most occasions). Of the nine subjects who underwent this procedure, conditioning of various degrees was manifested in seven. Of these all showed a statistically reliable, though psychophysically small, tone-contingent shift of hue perception (in the predicted direction) as an after-effect. Conditioning did not occur in the other two but neither was there any tone-contingent shift in colour perception.

In the second case, the puzzle-environment was again under computer control, but this time the task of the subject was to inspect pairs of coloured lights through each of two different filters. The first member of each pair could be seen only through a filter on the left, and the second only through a (complementary) filter on the right. The first of the two stimulus lights was switched on (by the computer) when and only when the subject's head was turned to the left; and the second only when the head was turned to the right. The subject's stated task was to

judge, from the appearance of the transformed photic stimuli, whether the lights at the source were the same or different in colour. This judgement was transmitted by pressing one of two response keys, upon which a negative or positive feedback signal was delivered by the computer. Scores of accuracy and speed were taken as criteria of adaptation. Two subjects on whom this task was imposed showed significant increments of learning and in both cases there were gaze-contingent shifts in hue perception as an after-effect which were both statistically reliable and psychophysically significant, ranging in size from small to moderate, which lasted for several days.

The results supported both hypotheses.

The interpretation of these and subsidiary findings resulted in a sharpening of certain notions which are fundamental to an understanding of Taylor's novel approach to colour. The most important are the following.

1. Colour can be understood in the context of a cybernetic model of organismic functioning, of which Ashby's (1952) is a convenient example.
2. If the equilibrium of the subsystem to which colour belongs is disrupted, there is a tendency for a new stability to develop. This property of "ultrastability" results in the formation of new functional equivalence classes: the individual develops a new behavioural equilibrium and acquires new colour constancies.
3. During the actual process of disruption, that is, in the transition stage between an old equilibrium and a new, the "normal" temporal relation between stimulus, perception, response and reinforcement may undergo radical changes, the most important of which is this: the subject may report his perception as being temporally posterior, rather than prior, to his response. This is interpreted as providing direct support for certain hypotheses central to the behavioural theory of the development of perception. The first of these is that perception is a function of learned behaviour. The second is that perception is equivalent to a state of response-readiness. Applied to colour, perception is a readiness to select an accurate and rapidly executed singular verbal and/or motor response, from a range of alternative responses, to the operating compound afferent input, made up not only of the chromatic stimulus but also of non-

retinal stimuli, including proprioceptive and interoceptive stimuli as well as any critical conditioned stimuli.

4. The formation of a new and stable colour constancy implies that the non-retinal stimuli will have been incorporated into the functional equivalence classes of the chromatic stimuli in such a way that the subject reports his new experience in terms of colour only: the non-retinal afferents will have dropped out of consciousness.

5. The "immediacy" of the experience of colour is a function of the stability of the functional equivalence classes which have been built up as a result of the adaptation of the relevant subsystem to the demands of the new environment. If there is competition between the new response-readiness thus developed and other readinesses, and if the new response-readiness has not achieved the requisite degree of stability, then immediacy is threatened. Intervening response-readinesses may be designated as "mediates", and their operation will serve to attenuate or even eliminate new constancies.

6. A potent source of such mediates in a self-conscious organism is a change of drive-state which results, for example, in the directing of responses to the critical non-retinal afferents (in these studies the acoustic stimuli and the neck-muscle proprioceptive afferents respectively). This may result in a partial or complete inhibition of the new immediacy and a reversion to pre-experimental colour perception.

7. If the drive-state of the subject is such that mediates operate extensively throughout the course of an experiment designed to disrupt ultrastability and bring about a new equilibrium (e.g. as in the wearing of bi-coloured spectacles) then it is possible that no such disruption will occur and no new constancy will develop. (The elimination of unwanted mediates is a practical problem calling for strategies which depend on some knowledge of the idiosyncracies of the individual subject).

8. Even in the absence of mediates, however, experimental distortion of the chromatic field may not cause disruption of ultrastability if the conditions of the experiment do not oblige the subject to rely on discriminable chromatic stimuli. There may be individual differences (among colour-normal subjects) in the ability to maintain adaptation via alternate channels of information. Non-reliance on the chromatic channel

may be designated "colour agnosticism". If alternate channels are closed, however, and if the chromatic channels are subjected to distortion, disruption of ultrastability will sooner or later occur.

Certain implications flow from this new mode of apprehending colour, among which the following are the most general.

The immediacy of the experience of colour has misled philosophers, psychologists and linguists into regarding colour as a primordial "given". In their attempts to reconcile this quality with the many "anomalies" of colour phenomena, e.g. simultaneous and successive contrast, colour constancy, adaptation effects, etc., they have employed a variety of stratagems and explanatory concepts designed "to save the appearances". Examples cited were, (1) the denial of the phenomenal order and the flight to a terminal-event type of behaviourism, in which only an account of discrete overt discriminatory responses is regarded as admissible, (2) the flight to physics, in which only the physicist's account of the radiant energy properties of colour is regarded as admissible, (3) the flight to neurophysiology, in which only the momentary state of the relevant retinal-neural processes is regarded as admissible, (4) the flight to language, in which only the analysis of semantic categorizations is regarded as admissible.

These, in turn, have given rise to the neglect, by psychologists, linguists, and anthropologists of the consideration of the possibility that colour has emerged from a special property of the multistable system to acquire, from infancy onwards, a stable field with respect to the relevant subsystem, as a result of certain organism-environment interactions. It was shown that consideration of colour in a cybernetic context involves taking into account not only the physical referent space, the behavioural space and the semantic space, but also, and primarily, the phenomenal space, in which due attention is given to consciousness itself as a legitimate field of enquiry.

Finally, the inconsistencies in the axiomatic foundations on which the science of colour has attempted to erect its structure were contrasted with the explicitly formulated axioms of J.G. Taylor, in the adoption of which (as the interpretation of the presented empirical evidence attests) such inconsistencies disappear.

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Chapter 1. Axioms for a Science of Colour

For the most part the history of sensory research... has consisted in following stimulation in from the outside, of specifying the effective stimulus more and more proximally.

(Boring, 1950, p.677)

I open with Boring's comment because it exemplifies not only the history, but the axiomatic basis, of sensory research (and nowhere more consistently than in colour) right up to the present day. Another way of putting this, with specific reference to colour, is to say that investigators have fastened on the properties of the retina (and its associated neural processes) as a complex transducer-decoder of photic stimuli; the assumption being that this is a necessary and sufficient condition for the understanding of human colour experience.

There still exists the belief that if you could get properly differentiated patterns of excitation to appropriate cortical centers, perception would occur.

(p.677)

Boring ironically comments that "at this point in the argument a dualist slips into the brain an homunculus ex machina to perceive what it is the nerves have brought in"! But he is speaking here in the context of the perception of orientation:- "the question as to why we see right side up when the retinal image, inverted by the lens, is

upside down. For three centuries," he says, "this pseudo-problem has plagued psychology."

Is his commentary as scathing when he is dealing with philosophers' and psychologists' efforts to understand the nature of colour and its "stimulus"? Not so. Like most present-day psychologists, Boring seems to accept that colour is "one of the properties of the primitive unmediated consciousness", a premise ascribed by Taylor (1962, p.313) to Hebb.

What are the historical origins of the virtually unquestioned assumption about this experience of ours when suitable "stimulation from the outside" occurs? Boring himself provides the answer.

...the first important knowledge of color and its stimulus was contributed by Newton... There was before Newton no satisfactory theory of color... It took the genius of Newton to discover that color is simple and fundamental...

(Boring, 1942, v-vii)

We do not need to be reminded of how Newton made this discovery, nor is it necessary for our purpose to go back before his time in order to establish the quite revolutionary nature of his conception. That Newton's own words, written 300 years ago, have an astonishingly modern ring, is something that we do need to be reminded of:

If at any time I speak of light and rays as coloured... I would be understood to speak not philosophically and properly, but grossly, and according to such conceptions as vulgar people ...would be apt to frame. For the rays to speak properly are not coloured. In them there is nothing else than a certain power and disposition to stir up a sensation of this or that colour.

(From Newton's Opticks, cited by Mundle, 1971)

Newton's genius gave to physics—and to psychology—a paradigm for colour which has remained basically intact for three centuries. The paradigm is simple and elegant. Phrased in a more modern idiom, it goes:- "The sensation of hue (or chromaticness) is a monotonic function of the dominant wavelength of the photic stimulus". This statement is

not, of course, to be understood as a formula which gives us direct information, or makes exact predictions, concerning the nature of any given hue response. Paradigms are not, of course, meant to do that. Their function, as Kuhn's (1962) now famous exposition tells us, is rather to provide a setting, an anchor, a stable framework of reference which shapes the kinds of questions which workers in that discipline will ask, the kinds of experiments they are likely to conduct, and the pattern or flavour (to put it at its mildest) of their theoretical conclusions. The paradigm, in short, defines the science and vouchsafes its conventions.

In fact, having accepted (or been "born into") a particular paradigm, investigators within that discipline may spend most of their time examining discrepancies, anomalies and apparent departures from the paradigm. But as long as these can be accommodated in some manner or another, at one or other point in the continuum between comfort and precariousness, into the prevailing system, the paradigm itself goes unchallenged. Under what conditions, one may ask, does one paradigm give way to another? Kuhn has given us a tentative answer. When the volume or the character of phenomena which do not easily fit the paradigm becomes quite pronounced, and, in addition, rival paradigms appear on the scene which are seen by sufficient numbers of investigators and students to have merit then a "crisis" occurs. If one of these competing paradigms wins the day--and the "day" may take a hundred years, as was the case during the phlogiston era in chemistry--a scientific revolution has occurred.

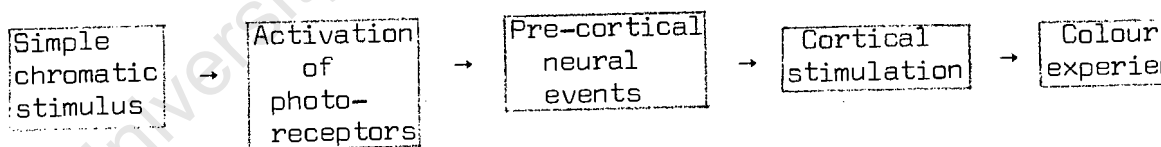
One of the prime aims of the present study is to question the paradigm (or axiomatic basis) of present-day psychological conceptions of colour. Instead of appealing to a large catalogue of contra-paradigmatic phenomena, however, I shall proceed by focussing on only two prototypical studies (and their offshoots), the character of which, I shall argue, are such that they call into question the underlying assumptions of extant theories. Another and even more important objective is to refer to a new and radical concept of colour, that of James G. Taylor (1962), and subject certain deductions from his theory to a logical and empirical scrutiny. By relating the studies to be described to Taylor's explicitly stated axioms, I hope to establish whether or not his own notions are sufficiently viable to pose a threat to certain deep-rooted modes of apprehending the nature of colour which prevail today.

Before dealing with Taylor's own axioms, it is necessary to trace quite briefly the metatheoretical lineage from Newton to present-day "color science".

The most important historical link between the concept of the "power and disposition" (attributed to their respective 'refrangibilities') of certain rays of light to "stir up a sensation of this or that colour" and today's tenets is, of course, Johannes Müller. In 1826 he presented his formal theory of "specific sense energies" or the "Law of Specific Energies of Nerves", as he was later to describe it. He held that the differences in the modalities were due to differences in the neurones leading from the receptors.

Later experiments showed that stimulation at different cortical sites was sufficient to produce different qualities of sensation or perception, which led Helmholtz to amend the Müllerian doctrine and ascribe the differences to the different sensory projection areas of the cortex rather than the afferent neurones leading to it.

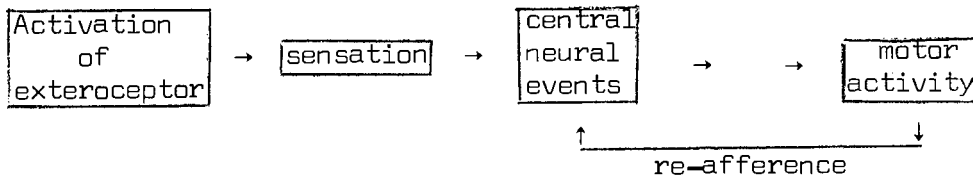
The Müller-Helmholtz paradigm which underlies virtually all modern treatments of colour can be represented thus:-



Different theories depart from the linearity of this model in different ways, the most distinguished of them being that of Jameson and Hurvich (e.g. Hurvich & Jameson, 1957). I hope that it will become clear, however, that the addition of interaction and re-afferentation loops, of whatever complexity, does not affect the basic paradigm.

To do this I should like to turn to Hebb². Since Hebb is not noted for any specific contributions to colour theory, this may at first seem strange. But if we bear in mind that a paradigm is characterized not only by what it sanctions, but also by what it prohibits (albeit tacitly), the reason for the inclusion of Hebb in the argument will become apparent.

It will not, I submit, be a caricature of Hebb's position if I represent his model of perception as follows:-



The sector of this diagram which corresponds to "central neural events" represents, for Hebb, the physiological basis of perception. The feedback loop indicates that perception of shape (in particular) cannot occur in the absence of some kind of motor learning. Hebb, in other words, has clearly amended the Müller-Helmholtz model insofar as "complex perceptual phenomena" are concerned—but not at all as far as "sensation" is concerned. In the Organization of Behavior, Hebb (1949) specifically distinguishes between "(1) a primitive, sensorily determined unity, (2) a nonsensory unity, affected by experience, and (3) the identity (also affected by experience) of a perceived figure (p.19)". Moreover, he cites von Senden's (1960) accounts of the behaviour of patients who have undergone cataract operations as confirming his belief that colour, unlike shape, for example, belongs to the "primitive, sensorily determined unity". What this means, and what nearly everyone involved in "sensory research" today accepts as a truism, is that the basic experience of colour, in its most reduced form, is immediate and has nothing whatever to do with the organism's peripheral motor responses. Because his model makes a clear-cut distinction between "sensation" and "perception", and because he specifically excludes the former from the influence of motor refference, I shall characterize the prevailing outlook as belonging to the Müller-Helmholtz-Hebb lineage; or, more briefly, I shall refer to the "M-H-H axioms" as those which underly current research and theory in sensory phenomena generally, and colour in particular.

The axioms on which a discipline rests are not always clearly enunciated by practioners and theorists within the discipline. Paradigms, and even large-scale paradigm shifts (what Kuhn calls "revolutions"), are sometimes invisible to the very people who are involved in them. In our own more self-conscious era, and certainly in the last 15 years, with the burgeoning of interest in the history and philosophy of science, this has become less true. In fact, already

in 1896 G.E. Müller laid down five so-called "psychophysical axioms" which provided a fairly explicit basis for what was then spoken of as "psychophysical parallelism", but which Boring (1941) refers to as "psychoneural isomorphism". In this paper Boring seeks to translate a "dualistic" set of axioms into a set acceptable to a "monistic positivist". It would take us too far afield to explore all the implications of Müller's axioms and the "operational reductions" which Boring performs on them. I am satisfied that nothing in them goes counter to the M-H-H paradigm. Boring's gloss represents very well, in fact, what a modern physiological psychologist would be fully prepared to subscribe to.

More pertinent to our present quest is to see whether, in the field of colour, there exists a similar formulation of fundamental propositions that would be generally regarded as unimpeachable.

There does. In 1954 the Inter-Society Color Council appointed a subcommittee to prepare "a statement of the basic principles which should be included in any elementary teaching of color". This task was interpreted by Burnham, Hanes and Bartleson (1963) to mean the provision of "a detailed outline of the facts, as distinguished from the fancy, of color...and...a basis for writing textbooks on color (p. v-vii)".

Although the authors say that their outline is "simply a collection of existing items of knowledge", it turns out that it serves admirably to illustrate one of Kuhn's contentions, namely that "standard textbooks" enshrine the paradigm which prevail during any given period of "normal science".

Since their plan was "to proceed from an organized inventory of basic and relatively unquestioned facts" towards progressively more "marginal facts or facts on which there is less general agreement", we have what is virtually a hierarchy of fundamentals in terms of the allegiance they can be expected to command from colour-scientists in general. The authors have devoted just over 200 pages to this enterprise, so the page numbers of the following quotations will serve as a rough scaling device.

Color is typically seen when a color stimulus acts on the receptors in the eyes and they in turn set off activity in the nervous system which ends in the color response. (p.17)

Since energy interchanges progress serially from a stimulus-object toward the person being stimulated, stimuli can be more or less proximal, i.e. near the nervous system (or its higher 'awareness' centers). (p.17)

'The' color stimulus, if it exists at all, is in the strictest sense the last energy exchange preceding an awareness of color. (p.18)

The occipital cortex...is the anatomical end of the nerve pathways related to color vision. When activity in the optic radiations reaches the occipital cortex, a conscious color response is produced. (p.47)

Conscious responses are awarenesses that result when the brain is activated. (p.48-49)

Color is an abstraction from a visual type of conscious response which depends directly upon activity in the nervous system typically produced by stimulation of the retina by light. (p.49)

Color sensation may be regarded as the least complicated case or prototype of color perceptions, in the sense that it involves the least interpretation in terms of past experience... The film mode of appearance is considered to be the simplest of all modes in the sense that it is the least removed from pure sensation. (p.50-51)

The hue of a color usually (but not always) depends primarily on the particular wavelength distribution of the light acting on the eye. (p.55)

I believe that most colour scientists would agree that these are the kinds of statements to be expected in a primer on colour. They would, of course, want to attach numerous qualifications to each of them (Burnham et al. go on to do this themselves), but I think that they would agree that the propositions are soundly expressed.

They would also, I believe, agree that these foundations fall well within the broader M-H-H paradigm. Before we go on to discuss the rival paradigm of J.G. Taylor, however, it is necessary to deal with the question of paradigms in colour theory per se.

I refer here to the fact that

...for more than a hundred years now, the views of two giants—Helmholtz and Hering—have continued to compete in seemingly irreconcilable and interminable disagreement on fundamental aspects of the visual mechanism and its functioning.

(Hurvich and Jameson, 1969)

The picture that Hurvich and Jameson paint in this (and many other of their publications) is one of paradigm clash—which is certainly not what Kuhn would characterize as "normal science". But there are paradigms within paradigms. We can illustrate this by using our ad hoc scaling technique. Burnham et al. discuss the Young-Helmholtz three-component theory and the Hering opponent-colours theory, on p.180 and 181 respectively, in their third and final section headed, "Marginal Facts". Although Kuhn has been criticized for using the term paradigm in too protean a manner, there need be no confusion about how it is being used here. If there is it will soon be dissipated when we deal with Taylor's axioms, which are superordinate to controversies concerning the structure and function of the retinal-neural apparatus. (On the other hand, Taylor's theory of colour-perception may well contain elements which touch on the Helmholtz-Hering clash, and we shall have to exercise caution in order not to confuse our levels of discourse.)

Although I imagine that the elaboration by Jameson and Hurvich of the original Hering theory would find a more comfortable home within Taylor's axioms than within the M-H-H axioms, this is not a view which these authors themselves might take. They are concerned with establishing a goodness of fit between the mechanism of our visual response system with its associated colour-coding functions and the way we actually report our experiences of colour; and they reject the "point-for point, stimulus-response paradigm" underlying the Young-Helmholtz the

We can sum up the matter by saying that whatever transducer-decoder paradigm wins the day, it will not, by itself affect what is at issue between the M-H-H axioms and those of Taylor.

In his paper, "The Role of Axioms in Psychological Theory", Taylor (1968) sets out to demonstrate that "the axiomatic foundation of present-day psychology...generates so many contradictions that one marvels that so few psychologists seem to be perturbed by it". He then suggests an alternate set of axioms which "are not torn assunder by contradictions of the type so frequently encountered".

He begins by noting that a system or "abstract structure" whether in mathematics or in science usually contains a number of axioms each of which is unproved and "not in any sense an absolute truth". When confronted with such a system (or model, in the broad connotation of that term) the most we can do is examine its logical coherence. If we discover contradictions between the several axioms, or between deductions mediated by them, then such a structure can have no formal existence and we must devise another.

He then relates this notion to psychology.

Before the advent of behaviourism psychology rested firmly on two propositions that in practice played the part of axioms, although they were not recognized as such, because they were considered to be self-evident truths that nobody in his senses would venture to deny... The first of these propositions, which dates back at least as far as Plato, is that the actions of a conscious organism are governed by mind. We may call it the mind-over-body (or m-o-b) axiom.

The second proposition is of more recent origin and it is concerned with the source of conscious experience. In the middle of the 17th century Descartes had formulated his famous theory, of two substances, *res extensa* and *res cogitans*, or matter and mind, which had no properties in common and yet could interact with one another. The Cartesian philosophy was a classic example of a structure that cannot exist because its axioms generate contradictory deductions...

(Taylor, 1968)

It is the dilemma of Cartesian dualism that is of greater interest to us in this context. Taylor suggests that a way out was seen to be afforded by the Müller-Helmholtz paradigm, so that "physiologists were

soon convinced that all the varieties of conscious experience were generated by specialized areas of the brain. He does not go on to show how Boring (1941) had operationized G.E. Müller's careful restatement of the paradigm, but he leaves us in no doubt that the solution is, for him at any rate, still quite inadequate.

The m-o-b and [Müller-Helmholtz] axioms together provided an escape from the contradictions of the Cartesian system. For if consciousness is generated in the brain, by some process analogous to secretion, there is nothing to prevent this product of brain action from exerting an influence on the motor apparatus and thereby controlling the behaviour of the organism. But the new system had still to be tested, and it was not long before it too began to generate contradictions.

(Taylor, 1968)

We need not be detained by examples of such contradictions. Taylor goes on to claim that when Watson rejected Cartesian dualism his manifesto had the unfortunate effect that it inhibited the efforts of scientific psychologists from continuing with the quite legitimate task of the study of conscious phenomena.

Behaviourism emerged out of experiments on animals. Since the subjects could not report on their conscious experiences, the old axioms were irrelevant and could safely be swept aside. This action was understood by many traditional psychologists as involving a denial of the existence of conscious phenomena, and J.B. Watson seemed to confirm this in his "Psychology from the Standpoint of a Behaviourist". He explained that he was rejecting Cartesian dualism and adopting a strictly monistic philosophy. Hence no terms referring to conscious events would be included in his work. He was apparently unaware of the fact that psychophysical dualism had already been killed by the general acceptance of the [Müller-Helmholtz] axiom which presented consciousness as a product of physiological action. His opponents were equally blind to this fact, and therefore read Watson's attack on the Cartesian 'mind' as meaning that the essence of behaviourism was the denial of consciousness...

Even the limited success achieved by behaviourism had a profound effect on those who insisted that subjective phenomena should continue to be an important sector of the psychologist's field of

interest. They could not escape the conclusion that the boundaries of their discipline had to be extended to include behaviour, or that in this field the methods of behaviourism had to be recognized and accepted. At the same time they failed to see how the laws of behaviour could account for the genesis of consciousness, or for the obvious fact that much of our behaviour is guided by consciousness. Hence, there appeared to be no alternative to the continuing acceptance of the m-o-b and [Müller-Helmholtz] axioms.

(Taylor, 1968)

Taylor comes to the conclusion that the axiomatic "system" which prevails in current psychological research is one which vainly attempts to include the axioms of behaviour theory together with the m-o-b and Müller-Helmholtz axioms. Such a system lacks coherence but he rejects two of the suggested alternatives to save the situation: (a) a phenomenology divorced from a material mechanism, but also, (b) a terminal-event kind of behaviourism that excludes conscious phenomena.

We cannot resolve this dilemma by throwing out the axioms of behaviour theory, because the resulting abstract system would refer to psychic events occurring not in the context of a living and behaving organism but in a vacuum. But neither can we resolve it by the simple act of sweeping aside the axioms of traditional psychology and putting nothing in their place. That is precisely what the early behaviourists did, and the result was a psychology without a psyche.

(Taylor, 1968)

We arrive at the point where he is ready to offer a new system "containing axioms that will generate propositions about conscious experience that do not conflict with propositions derived from the behavioural axioms." The system he formulates is the following.

Axioms for a conscious organism

A. Axioms of behaviour theory [not enumerated]

Definition: A state of readiness for a given learned response is defined as a state of activity, induced by the conditioned stimulus, in the cerebral links mediating the response. This state of readiness exists whether the response is evoked or not. States of readiness for two or more different responses may exist

simultaneously, in which case the organism is in a state of multiple simultaneous readiness.

B. Axioms relating to consciousness

(1) The state of multiple simultaneous readiness that exists at any moment determines the state of consciousness at that moment.

(2) States of readiness for two responses that are clearly distinguishable from one another determine two different elements of consciousness.

(3) If two different patterns of stimulation arouse readiness for responses that have common features, the associated elements of consciousness are to that extent alike.

(Taylor, 1968)

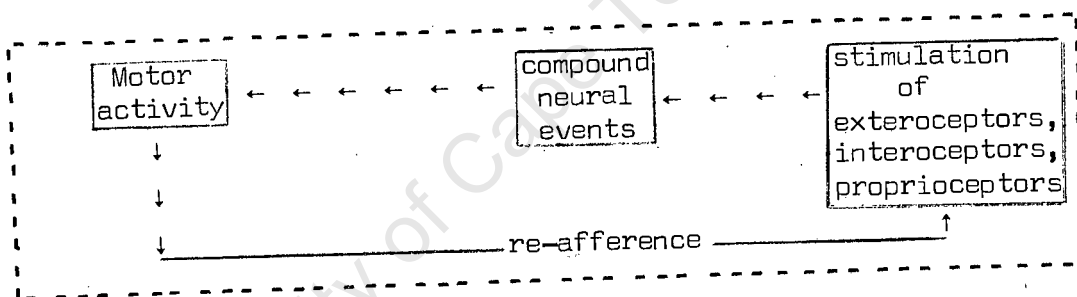
I have provided rather lengthy quotations from this paper because it presents us with a paradigm which to my knowledge is quite unique in psychology but which is nonetheless not widely known nor appreciated by psychologists in general. I do not, however, intend to provide a general critique or appreciation of it myself. What I should like to end with is a brief indication of how Taylor's axioms differ from the M-H-H axioms, and what the general implications are for colour, as an aspect of human behaviour and experience.

The first point to note is that Taylor does not reject a neural foundation for either behaviour or experience. What his axioms lead us to is a view of the function of the nervous system in which the formation of "cerebral links" is a product of adaptation to the environment through the various processes of learning. Psychoneural isomorphism or parallelism is inadequate because it carries the implication that by ever finer histological examination of nerve tissue we shall one day find out exactly how the human machine works. That, he wants to argue, is putting the cart before the horse.

Unlike other machines, organisms (like ourselves) that have extremely wide limits of adaptation are not constructed in an articulated fashion that can be reductively understood. Unless we comprehend the totality of a given organism's history of adaptation, the brain, as a mechanism, can never make sense, since it must vary from one individual to another in sometimes highly idiosyncratic ways. The fact that we find certain uniformities in the mature organism is to be attributed to corresponding uniformities in prior patterns of

learned behaviour. These behavioural readinesses are chronicled, as it were, in the neural structures of the cortex; and the activity of these structures serve, in turn, to mediate a great variety of covert and overt responses. These responses cannot be evoked simultaneously but it is the "multiple simultaneous readiness for response" that constitutes the bridge from behaviour to experience.

Moreover, experience is not a mere function of exteroceptive stimulation. The state of readiness which is axiomatically identified with perception is one which can lead to any of the responses that have been conditioned to the total (compound) afferent input in operation at the moment. Stimulation of the exteroceptors is necessary, but not sufficient. In a very rudimentary way, and by way of contrast with the M-H-H model, we can characterise Taylor's model of perception by means of the following diagram:-



This constitutes a cyclic event, a perceptual building block, which results in the gradual organization from birth onwards, of certain stable efferent-afferent relationships called functional equivalence classes³ which correspond both to behavioural equilibrium and the "constancies" of perception.

It serves not only the so-called complex modes of perception, but also "the simplest of all modes", those according to Burnham et al (1963) that are "the least removed from pure sensation" namely, colour in the aperture or film mode. Taylor's thoroughgoing consistency in this respect is without parallel. The distinction between sensation and perception disappears; neither can occur except as a function of learned behaviour.

To understand how Taylor conceptualizes colour as a state of readiness for certain kinds of motor responses, I shall in the next chapter outline those parts of his theory which are relevant to this question and see what deductions they mediate.

We may end this chapter by going back to Newton. The M-H-H axioms and the "basic facts and concepts" of colour science are axiomatically in keeping with Newton's conception that a ray of light of a given "refrangibility" will, by virtue of its intrinsic "power", excite the sensorium to produce a given colour experience. With Taylor we encounter what I would judge to be a paradigm shift of major, even revolutionary, proportions. No stimulus, not even the most "elementary" has, by virtue of any physical property it possesses, the intrinsic power to affect a receptor (no matter how finely tuned to the stimulus energies that receptor may be) in such a way that the automatic result is a given conscious experience. And colour--even at its rawest--is no exception. Human experience is a function of learned behaviour. The adult organism is not conscious of the history (from birth) of its multifarious modes of commerce with its environment. Nonetheless, this history is there. But it is written into the brain in such a way that our response (to a given colour stimulus, say) seems to be "im-mediate". It is this immediacy which (so Taylor's axioms imply) traps us into making Newton's assumption that powers in the external world can ipso facto stir up sensations in the inner. The "powers" are there; but they are not "in" the environment; and they are not "in" the organism; they are a product of a long series of organism-environment interactions.

Even when we can "understand" Taylor's position, we will find that it is not an easy one to assimilate. As far as colour is concerned, most of us are still on Newton's back. It is a tribute to him that we find it so hard to get off. It will be no tribute to us if, on being offered a more commanding range of view, we should want to cling to an old security.

1. The factors that determine whether a competing paradigm will be seen to "have merit" are according to Kuhn, exceedingly complex. Briefly, his position is that in addition to empirical and logical considerations, a host of psychological, sociological, historical, economic and other forces play a part in the process.
2. I am specifically indebted to Glynne Hirschmann for helping me to understand Hebb's role in current colour paradigms.
3. See p.142 for a discussion of the key-concept of functional equivalence classes in Taylor's system.

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Chapter 2. A New Concept of Colour: Taylor

In this chapter I should like to examine the nature of certain deductions and implications that flow from Taylor's theory of colour perception. Some of these are contained in the chapter devoted to colour in his book "The Behavioral Basis of Perception" (Taylor 1962); others stem from my own interest in his theory but are not of a kind that can be put to any simple empirical test. I have called them "thought experiments" because I believe them to have the same kind of heuristic value that these devices have shown to serve in physics.

What I shall not do is outline Taylor's overall theory of colour perception. There are a number of reasons for this decision. Taylor's book (in the preparation of which he spent some fifteen years) is mainly concerned with our perception of the spatial ordering of the material environment. A full appreciation of his colour theory depends on an understanding of the nature of the development by the young child of a certain class of responses directed towards objects which are initially responded to in terms of size, shape and other spatial constancies. It is to the development of these constancies that Taylor has devoted the main body of his work. In order to expound his colour theory in full, it would be necessary to give a reasonably systematic account of the basic theory contained in the previous nine chapters of the book. In fact, a reader who decided that he was interested only in Taylor's colour theory would find that Chapter 10 is not a self-contained account. It refers back (in set theory notation) to concepts previously defined and

discussed in a manner which obviously assumes the reader's complete comprehension of those concepts. To provide such a background would be to swell the size of this thesis beyond reasonable dimensions. But there is an even more cogent reason for my not undertaking such a task: I lack the necessary qualifications. Fascinating as I find his theory, there are many, possibly crucial, places where I can follow him only at a distance.

This impediment does not turn out to be as alarming as it sounds. Taylor has not only spelled out his axioms quite explicitly (Taylor, 1968) but he has in several places (e.g. Taylor, 1957, 1964, 1970; Taylor & Wolpe, 1962) given summary accounts of the main thrust of his theory. Moreover, there exist at least two critiques (Farrell, 1965; Hochberg, 1965) and a review (Pratt, 1963) which have enabled me to match my own comprehension and evaluation of his work with those of others. Had it emerged from a perusal of these subsidiary sources that there was a fundamental irreconcilability, I would not have embarked on this work to begin with. Apart from these considerations, I believed that since Taylor's conceptual framework was of a radically different nature from any prevailing in psychology today, it was not sufficient to study the theory; it was necessary to work through some of its empirical implications. I had already made one attempt (Abramovitz, 1962; to be mentioned in the next chapter) which confirmed Samuel Alexander's dictum that "we do not do because we know; but we know because we do", and the experiments I undertook for the present work resulted in an even firmer corroboration.

But there are still other reasons. Even had I been able to claim a detailed understanding of the main theory, there are certain aspects of his colour theory (e.g. his treatment of simultaneous and successive colour contrast) which require for their proper evaluation a background which I have been unable to acquire. My main motive in choosing colour, in fact, was not primarily because of a specific interest in that field, but rather because Taylor's conception of "sensation" in general, and the modalities in particular, seemed to have startling implications for epistemology as well as psychology.

To return to the theme of the present chapter, it is necessary to realise at the outset that Taylor is above all concerned with the "stabilities" or constancies of colour perception and that his theory is therefore necessarily a developmental one.

...the composition of the light reflected by any object is not constant but undergoes an endless succession of transformations according to the contributions made to the incident light by colored objects in the environment...
The fact that we are aware of nothing of all this in our daily lives but obstinately see the apple as having the same red color in all circumstances constitutes a challenge to science. Our first problem in dealing with the perception of color must therefore be to discover the source of this remarkable constancy.

(Taylor, 1962, p.234-5)

Taylor maintains that the development of these constancies cannot begin until "adequate responses to the spatial ordering of the environment have been established".

It is clear that we cannot maintain the view that colours are subjective experiences fully determined by retinal processes, and that perception is the resultant of a process whereby those subjective experiences are externalized and given "a local habitation and a name"; for it is difficult to see how a local habitation can be assigned to a subjective experience that is liable to vary from moment to moment. It seems more reasonable to assume that the habitation is constructed first and the paint is put on afterward. Our problem will then be to disclose, if possible, the technique of the painter.

(p.237)

He goes on to speculate that it is not until the child is involved in a choice (on grounds other than colour) between one or more responses toward an object reflecting a selective range of wavelengths and experiences the consequence (unrelated to colour) of making one or other response, that he has the opportunity of acquiring the foundations of colour perception.

Taylor's specification of the nature of the choice situations which are critical for the child's acquisition of colour-perception is frankly conjectural. He believes that the earliest and simplest of such responses is the reaching for an object in order to eat it. The accompanying retinal stimulation becomes conditional to these reaching responses, the reinforcing agency being the varied effects of eating (or attempting to eat) the object chosen.

The main implication of his argument is that

...color is a perceptual property involving the activity of engrams mediating responses of which the essential feature is choice from among a number of alternatives, the stimulus being the wave composition of the light reflected by the several objects between which the choice can be made.

A second implication flows from the character of the behavior that is conditioned to the wave composition of the light. Unlike the behavior [that generates perception of the spatial ordering of the environment] this is not quantitatively graduated to adapt to quantities measured along some continuous physical scale. It is true that wavelength is measured by such a scale, but the behavior in question does not vary continuously with wave length. On the contrary, the same response may be evoked by any one of a collection of lights that would be matched with lights taken from a substantial range of the spectrum. Moreover, the same response may, under different conditions of organic need, be evoked by any one of an entirely different range of lights. The response, although it is evoked by the wave composition of the light, is not in any sense related to wave length; it is related to the relevance of the substance reflecting the light to the organic needs of the body. It is that relevance that is the source of the primary reinforcements on which the whole system is built. The essence of the behavior is selection, but what we select is not a wave length but a substance that is good to eat. Since, then, the behavior is not related to any variable that can be expressed in simple quantitative terms, we can deduce that the perceived colors do not fall into any obvious quantitative sequence, but are distinguished from one another qualitatively. (p.244)

Several other implications can be briefly mentioned.

An important one concerns colour perception and colour identification in young children. This is an issue on which the published empirical evidence is thoroughly confusing. Comprehensive reviews are provided by Peiper (1961) and by Kessen et al. (1970). The methodological problems (especially controlling for brightness) are such that almost no generalizations can be made across the wide variety of studies reported. But an even more important difficulty arises when it becomes apparent that different investigators interpret the problem in axiomatically different ways. To demonstrate that an infant of three months may sometimes "discriminate" between yellow and blue as measured

by some motor or autonomic reaction is, on Taylor's premises, no evidence at all of a perceptual stability. Why is it, Taylor asks, that an intelligent child of two finds it so difficult to learn to attach the right names to red, yellow, green and blue patches, when he is able to identify and label quite complex visual configurations, sometimes after only one or two attempts. His answer is that "the stabilization of color vision" depends on the organizing of functional equivalence classes (which may contain hundreds of elements) to singular (verbal) responses.

After citing other evidence (e.g. Howells, 1944) Taylor comes to the conclusion that language contributes to the refinement of colour perception. In a language that contains a rich vocabulary of colour names

...the number of available responses from which a selection can be made is enormously increased and the equivalence class defined by each name has a very much narrower range...the state of readiness for [a given] response that is induced by the action of any one of those elements is sufficient to generate perception of the relative color.

(p.248)

The necessary reinforcements are no longer those which are governed by the child's own bodily needs (as in eating); they now occur in a complex social context (cf. Skinner's "verbal community"). Language by itself is unlikely to be the medium whereby "color is created for the first time".

Taylor then deduces that since there has been a significant increase in the variety of colours of household objects in the last fifty years, children have had a progressively greater opportunity to learn to make correct colour identifications at earlier age-levels.

This seems to be confirmed by the fact that the test of naming the colors red, yellow, green and blue was assigned to a mental age of seven in the 1911 revision of the Binet-Simon scale for the measurement of intelligence. In Burt's version of the scale, published in 1921, the test was assigned to the age of five; and in the modern Terman-Merill scale it is placed at the age of three.

(p.248)

On the other hand, if the environmental conditions (e.g. uniformity of diet) under which a child is reared are of such a nature that his "freedom of choice" during the period when "color perception normally develops" is restricted in some critical way, then we can expect deviant reactions to colour. If the child learns to make his choices on the basis of cues other than the wave-composition of the photic stimuli (e.g. luminous reflectance, texture, etc.) this could result in "normal color vision being lost forever, since the alternative stimuli will generally suffice to mediate the appropriate choice, and there will not again be sufficient drive to allow responses to be conditioned to the composition of the light". Taylor predicts, on these grounds, that many cases of adult colour deviance may not be due to deficiencies or abnormalities in the retinal apparatus as such.

Taylor considers two specific studies in which unusual constancies were developed under highly artificial conditions, those of Howells (1944) and Kohler (1951) and shows how the actual results obtained might have been "predicted" or "deduced" by the behavioural theory. Since it is to these that the following two chapters are devoted, I shall not say anything about them here.

I believe that I have extracted enough from what Taylor has to say about colour to make it clear that his theory is capable of generating deductions which are eminently testable. Although it has been said (e.g. Hochberg, 1965) that Taylor's general theory is less vulnerable to empirical refutation than he himself cares to think, I believe otherwise. I think that it is possible to devise a whole array of "risky" experiments in the development of new constancies or functional equivalence classes relating to colour. I hope that the next two chapters will serve to demonstrate at least a beginning in this direction.

One of the features which characterize a new paradigm is, in fact, that it gives rise to new modes of intellectual enquiry, new modes of conducting research.

Led by a new paradigm, scientists adopt new instruments and look in new places. Even more important, during [paradigm shifts] scientists see new and different things when looking with familiar instruments in places they have looked before.

(Kuhn, 1962, p.111)

To illustrate my belief that Taylor's concept of colour does represent a discrete and disjunctive leap from the Müller-Helmholtz-Hebb cast of thought, I should like to present two or three thought experiments which form an important link between his axioms and the actual laboratory evidence still to be cited.

Although thought experiments have been quite common in disciplines like theoretical physics, they have not been deployed to any significant extent by psychologists. We must not of course confuse thought experiments with armchair speculations. Gamow provides the following characterization of the thought experiment:-

...a Gedankenexperiment ("thought experiment") [is] a device which was first used by Einstein in his discussion of the theory of relativity. In such an exercise the experimenter is allowed an "ideal workshop" in which he can make any kind of instrument or gadget—provided that its design and functioning do not contradict basic laws of physics. For example, he can have a rocket that moves with almost the speed of light, but not more than the speed of light: or he may use a light source which emits just a single photon, but not half a photon.

(Gamow, 1958)

Given an "ideal workshop", suppose that a child with completely intact retinal-neural processes were reared in an environment in which all the objects were achromatic, but where the illumination underwent continuous random changes, in terms of dominant wave-length, over the whole colour space. A normal adult observer would at any given instant see all objects as having the same chromaticness¹, but over a given length of time (say five minutes) would experience a good sampling of all the different chromaticities in the colour space—in the illumination mode, of course. Our child is thus not going to be deprived of varied chromatic stimulation.

The M-H-H model would have to predict that such a child will experience the various hues in a completely normal way. I would deduce from Taylor's theory, however, that he will in fact have no colour experiences and, if allowed to reach maturity in such an environment and later placed in a normal environment, will be functionally achromatic¹ even though the relevant retinal-neural structures would presumably still be intact.

We could actually perform an attenuated version of such an experiment if true monochrome spectacles could be devised. A miniature STL monochrome TV camera, if worn during the critical period for colour development (which Taylor does not specify but which we might as a first approximation put at 12 to 36 months) ought to result in a significant and perhaps even lasting loss of hue constancy.

A more promising (and ethical) possibility is to subject adult subjects with normal colour vision to a prolonged period of "deprivation" in the heterochromatically illuminated achromatic environment and subject them to a variety of discrimination tasks involving every kind of visual cue except of course wave-composition differentials. I would deduce from Taylor's theory that subjects who were not aware of the object of the experiment would (a) gradually become oblivious to the chromatic changes in illumination, and (b) on return to a normal environment would show a significant loss of colour discrimination.

These experiments describe conditions which are necessary for the inhibition or attenuation of colour constancy. A more rewarding exercise, in many ways, is to devise a thought experiment in which an "impossible" new constancy will have to develop. Impossible, that is, from the vantage point of the M-H-H paradigm.

In order to set the stage, it is necessary to refer to an actual experiment first reported by Taylor and Papert in 1956 and described in detail by Taylor (1962, p.195-207). The subject was Seymour Papert himself who undertook to wear left-right reversing spectacles for only the first half of each day. Taylor's behavioural theory generated the hypothesis that provided I could learn to direct adequate and accurate motor responses of various kinds to a wide variety of stimulus patterns he would eventually perceive the spatial ordering of the environment veridically whether he was wearing the spectacles or not. An essential component of the experiment was that the wearing or not-wearing of the spectacles was accompanied by an invariant afferent input, or its absence, respectively. This condition was satisfied by, among other things, the cutaneous stimuli attendant on wearing the distorting device. Papert was subjected to specially devised daily training procedures, with the result that after little more than a week both behavioural adaptation and the predicted perceptual constancy occurred. The theoretical implications of this outcome are of profound importance for understanding

Taylor's treatment of constancy, and I offer a corresponding thought experiment with colour as the analogue of laterality.

Suppose we could devise a prosthesis which when worn (perhaps like a contact lens) transformed the wave-composition of photic stimuli in such a way that all hues took on the appearance of their complementaries. Suppose further that the device could be "enabled" or "disabled" by telemetry and that when enabled, an arbitrary, independent input source (say a micro-miniature low-intensity audio-frequency generator in the ear) were simultaneously activated. Let a normal neonate be fitted with these devices (it being understood that no one except E knows of their existence) and be allowed to grow up in a completely normal environment.

The experiment is simple. Let the devices be enabled and disabled at midday and midnight respectively from the beginning of the child's life. Under such conditions Q will grow up so that for about half its waking hours the wave-composition of the light reaching the retina is "inverted", whereas for the rest of the time these afferents are unchanged.

What would supporters of the M-H-H transducer-decoder model say about the colour-experiences of such a child? They would surely be forced to say that he would grow up in a state of utter confusion about colour. Before lunch the sky is blue, grass is green and blood is red. After lunch the sky is yellow or orange, grass is mauve and blood is turquoise! And, although he might learn (after bitter and frustrating experiences) to attach the correct verbal labels to these and other chromatically discriminable objects, his colour experiences would retain their stubborn diurnal duality.

Taylor's cybernetic model, on the other hand, predicts completely normal colour development for such an individual--provided that the correlation between wave-composition inversion and acoustic input were maintained at unity. Moreover, the model would predict that if the enabling and disabling were randomly executed, at virtually any frequency (say up to 100 times a day), colour perception would still be quite normal. No colour-vision test could be devised which would establish a significant deviation from normal variability.

We shall have occasion to return to the implications of these thought experiments. They epitomise in a quite crucial way (if my deductions are sound) the difference between the 300-year-old Newtonian colour paradigm and the one which this thesis aims at expounding—that of James G. Taylor.

Notes

1. For the way in which colour and other technical terms are used in this thesis the reader is referred to the glossary at the end of the volume.

Chapter 3. Empirical Evidence: Conditioning of Tone-Contingent Hue Responses

3.1 Introduction: Thomas Howells

The experiments to be described in this and the next chapter stem from the work of two psychologists with very different philosophical and theoretical leanings. There are, however, links between them. In each case their work was seen by J.G. Taylor as belonging to the realm of fundamental research (as opposed to the "test-of-significance" type on which he heaped such scorn: Taylor, 1958); and in each case their names, fifteen years ago, were largely unknown among American psychologists. In Ivo Kohler's case, the reasons are probably to be sought in geography and language. In 1951 his monograph, Über Aufbau und Wandlungen der Wahrnehmungswelt, had been published in Austria and it was not until the Fiss translation in 1964 that confusion with his famous near-namesake, Wolfgang, began to wane. But what shall we say of Thomas Howells, who is to this day still not a household name? He was not only English-speaking, he was refreshingly literate: not only was he writing from a reputable University (Colorado), but his research was published in the Journal of Experimental Psychology. Yet, if number of citations is an index of a man's research influence, Howells was simply a non-starter; no one (going by the entries in Psychological Abstracts up to October 1971) followed up his work, and no psychological text or article that I have come across (except Taylor, 1958, 1962) has as much as mentioned him.

In a later chapter I shall briefly speculate on the phenomenon of one man in the community of scientific psychologists seizing with avidity on work which is, at the time, virtually ignored by the rest of that community. Let it suffice here to say that Taylor (1958) regarded Howells' demonstration of experimentally-produced tone-contingent changes in hue perception as "among the most important experiments in the history of psychology", whereas the reaction of most other psychologists, even today, would probably be, "Who is Howells?"

Howells' inclinations were towards environmentalism and functionalism, but, unlike some of his latter-day counterparts, he was interested inter alia, in the "qualities and meanings of sensations and perceptions". His report was first published in 1937 in the form of an abstract, and in 1944 as a full paper. It opens as follows: "The quality which has traditionally differentiated the psychologist from the unspoiled layman is his persistent endeavour to dissect experience". That sentence would have an old-fashioned ring among those experimental analysts of behaviour who confine themselves to terminal events and eschew, even despise, "mental way-stations". Like Taylor, Howells regarded the "qualia" of conscious experience as depending "in the long run upon how effectively they guide the total process of integration of the whole organism". Unlike Taylor, he was equivocal about the exact nature of the relationship between behaviour and experience. For Taylor "all conscious experience is a function of learned behavior" (1962, p.vii); but, although consciousness is the dependent variable, it is not on that account of a lower order; on the contrary, it is an emergent, and serves as "the final court of appeal" (p.344) in all knowledge including all the sciences. Howells, having referred to the "guiding" function of the attributes of consciousness, can speak of "sensations and perceptions as incidental to the overall process of organic adjustment" (emphasis added) which tends to convey an epiphenomenal point of view.

Because of Howells' obscurity, it is necessary to outline his study in some detail, and this will not be fully comprehensible unless the context is also furnished; so that is what we must start with.

3.2 Synaesthesia Before Howells

Until the 1930's the topic of synaesthesia was a fairly respectable one; it aroused considerable debate and speculation, especially among Continental psychologists, although curiously enough Boring's Sensation and Perception in the History of Psychology (1942) barely gives it a mention.

That the subject has had both curiosity as well as scientific value is without doubt. The modalities have traditionally been regarded as single-channel media serving qualitatively different varieties of experience, and Müller's doctrine of specific nerve energies was probably the first set of psychophysiological axioms to lend scientific respectability to the notion; (Helmholtz added the weight of his authority by asserting that between the domains of the single senses there is no communication). Yet the contrary notion, that intersensory or cross-modality phenomena, though attenuated or rare, are real and significant, has persisted.

One of the first to make explicit reference to it was apparently Goethe (1840) who mentioned a case of musical chromaesthesia previously described by L. Hoffman in 1786. The philosopher George Henry Lewes (1879) brought the topic into his emergence theory of mind. In 1926, and again in 1929, Langfeld contributed two short, curiously unsatisfying papers on the subject to the Psychological Bulletin. One of the major "experimental" analyses was that of Argelander (1927) whose monograph on "coloured hearing and the synaesthetic factor in perception"

included a bibliography of no less than 466 titles. His subjects were exposed to certain tones and vowels and simply asked to select colours which had appeared synoptically (i.e. as spontaneous instances of coloured hearing) or "which best matched the tone". Different sounds were claimed to correspond to specific colours and the results were said to correspond to those reported for "true" coloured hearing. Argelander argued on the basis of other evidence that every observation involves a synaesthetic factor.

Kelly (1934) was responsible for the first serious attempt to produce the phenomenon by what he called "the technique of the conditioned response". Because it was his failure that probably spurred Howells on to his own heroic efforts, I shall discuss it separately in connection with the Howells experiment.

Bornstein's (1936) contribution, "On the functional relations of the sense organs to one another and to the organism as a whole", leans unmistakably on gestalt principles. He quotes von Hornbostel extensively, who hypothesizes that "the faculty of perceiving bright and dark is a function common to [all] the fields of sense. To this there can correspond in the bodily field only an unspecified process". It is "an intermodal primitive function of all sense organs". [The term must obviously be understood as transcending its optical connotations.] Börnstein's method of testing this basic hypothesis is similar in style to Argelander, but his conclusions are always related to wholistic organismic functioning, namely, that

brightness-exciting stimuli have an effect not only in the same manner on all sense-organs, not only from the sense-organs upon the muscles, and vice versa from the muscles upon the eye, but there is induced by such stimuli a modification of the whole organism, which can be experimentally demonstrated on both human beings and animals by the most varied of methods.

By psychological means we can establish brightness as a perception content; by muscular-physiological examination we can prove displacement of tone; by histological scrutiny of the retina of the frog we can ascertain contraction of the retinal cones and movement of pigment... Brightness-excitation is at one and the same time a change of functional condition in the sense organs, in the bodily muscular system, in

the animalic [sic] , and most probably also
in the vegetative nervous system...

(Bornstein, 1936)

It is possible that this kind of over-enthusiastic gestalt-inspired gnosticism has served to impede rather than advance our understanding of intersensory functioning. At any rate, Müllerians were certainly not put to flight.

Neither, for that matter, were followers of Helmholtz dismayed by Hasebroek's (1935) explanation of coloured hearing in terms of Planck's quantum theory of light and the anatomical juxtaposition in the cortex of the auditory and visual areas.

Yet, in 1938, in a volume intended for the layman, Taylor headed a chapter, "We see with our eyes and our muscles", and went on to say, "... it might almost be asserted that we see with the nose, tongue, ears, fingers..., and in fact with the whole body". Taylor will later (1962) amplify these apparently wild assertions in a manner which ought at least to have made a small dent in the Müller-Helmholtz paradigm. Yet only now are his axioms concerning perception (which for him is fundamentally trans-modal and always involves what is now known as "re-afference") beginning to seep into the mainstream of psychology (see, for example, Festinger, 1967, and Gyr, 1972).

Howells' study, which aroused Taylor to such an extent, was curiously enough the end rather than the beginning of a chapter in the history of synaesthesia in American psychology. The term certainly went out of fashion; only one other specific reference (Ries, 1963) being traceable. What seems to have happened was that the phenomenon was taken out of its experiential context and reconceptualized or simply "operationalized", and we have, since then, studies and reviews using terms such as "intersensory processes" (Gorrell, 1953), "sensory interaction" (London, 1954), "sensory-tonic interdependence" (Werner and Wapner, 1955; 1957), "intersensory development" (Birch and Lefford, 1963), "intercorrelation of the senses" (Stone and Pangborn, 1968), "intermodality relations" (Warren and Pick, 1970) and "bisensory detection performance" (Loveless et al., 1970).

No attempt will be made to collate in detail what is now a very large mass of literature, because the central theme of the present study, experiential transformation through behavioural adaptation, is affected by very few of these findings, and then only tangentially¹.

Kelly's (1934) paper was a point of departure. His was probably the first serious attempt to produce what he called "artificial chromaesthesia" or "coloured hearing" by conditioning. He also provided a judicious review of previous literature on the subject. Briefly, his method consisted in asking subjects (mainly graduate psychology students who were fully aware of the aim and rationale of the experiment) to attend to paired tonal and chromatic stimuli for several hundred to 2000 trials with a mean of 996 trials each for 36 subjects and then to report whether the visual stimuli on their own produced any auditory effects (and vice versa).

We may note here that Howells' strictures on Kelly's methodology were not merely that his subjects were not called on to make any response to the stimuli, but that "his data were introspective reports". For Taylor, let it be emphasized, verbal reports are of paramount importance. If he calls them introspective, he expressly does not want to convey, as the early structuralists did, that his subjects are to comment on the mental processes accompanying their experiences; he merely asks them to say what it is they are experiencing. Quantification is not unimportant, but it comes later. First and foremost he wants to know such things as, Is it right way up or upside down? Is it on your left or on your right? Is it normally patterned or mirror imaged? Is it green or red (or neither)? Howells is again equivocal on this point because, as we shall see, his own data are for the most part scores of thousands of instances of people saying "red" or "green" when presented with different lights (contingent on different tones). Each of these "reports" is (for Taylor) "an introspection"—Q is describing what he is seeing. But they are also responses, which like any other motor response, are subject to being conditioned to contingent stimuli. For Taylor a verbalisation has a dual² mode: it can be either the dependent variable (in that it is usually the only or the best index we have of the nature of the individual's experience, or it can be the independent

variable (in that its modification by learning can mediate new perceptions). Curiously enough, Howells reaches the same conclusion when, in his discussion of his own results, he says, "Perhaps the best interpretation is that the verbal response was as much a means by which the perception was mediated as was the word a resultant of the perception". ____ Kelly failed in his attempts, but what if he had been successful? Supposing his subjects had said things like, "I have a distinct image of pink before me" (when the relevant auditory stimulus was presented). Would Howells have scorned this statement as not constituting appropriate and scientifically respectable evidence? We shall see how Taylor deals with this problem when the results of the present study are analysed and interpreted.

Howells' main quarrel with Kelly seems to have been that what the latter called "the technique of the conditioned response" was nothing of the kind, since the stimuli called forth no specific response which was "instrumental" in achieving "a psychological end or goal". But Kelly harked back to Pavlov rather than Thorndike for his warrant. Now, although it is true, in a manner of speaking, that a classically conditioned dog really does something about his "unconditional" (say, meat-powder) stimulus, namely he eats it, eating is not the "unconditional reflex" to meat-in-the-mouth. The UCR is salivation, in this context, and salivation (to use a more contemporary terminology) is a "respondent" rather than an "operant"—in spite of Neal Miller's demonstrations that the distinction is by no means as clear-cut as the older text books have led us to believe. Miller would nevertheless not want to say that the dog's training should have resulted in his eating the bell! Kelly's reasoning must have been: Bell paired with meat powder elicits salivation during conditioning trials; bell without meat-powder elicits salivation during test trials: tone A is to bell as colour B is to meat-powder. We don't have to ask our subjects to do anything other than listen and look. After all, did not Pavlov take special precautions to prevent all motor responses except eating (and tail-wagging, presumably!)? And is it not true that, in Pavlovian conditioning, it is the environment that does something to the organism whereas in instrumental conditioning the organism does something to ("leaves its mark on") the environment? If Kelly can be faulted, it is surely not that he didn't regard instrumental conditioning as the only variety of that phenomenon, but (a) that he uncritically plumped for a straight

temporal-contiguity S-S paradigm, and (b) that even granting him the validity of this paradigm, that he ignored or misinterpreted one of its prime requirements, namely: the organism must be in some relevant drive-state or motivation with respect to the initially "adequate" stimulus. But for what responses (or rather reactions) were his colour-stimuli adequate? We now know that colours are able to evoke such respondents as pupillary dilation (Miller, 1966) and GSR changes (Hernandez, 1940; Wilson, 1966) and it might have been a perfectly legitimate procedure to try to elicit one of these autonomic responses to auditory stimuli which originally failed to evoke them, but whether this would have resulted in a "chromaesthesia" is highly problematical.

Notes

1. A possible exception is Werner and Wapner's sensory-tonic theory of perception which does warrant some discussion, and receives it in the next chapter, p.160f.
2. In saying that for Taylor a verbalization has a dual mode I am not implying that there is a basic contradiction in his system. A behaviourally-orientated linguist would probably have no trouble with this apparent "duality", but I shall explore only a limited sector of the topic myself (see p.236f.).

3.3 Howells' Own Study

Howells started by formulating "a general hypothesis of synesthesia: namely, that synesthetic effects may be the result of an association or combination of sensori-motor activities, if and when they are functionally involved in a larger and longer process of organic adjustment or goal achievement, or in other words, if they are derived from a dynamic whole". He went on to suggest that such an approach might throw light on the more general hypothesis "that all sensory experience, including synesthetic, is instrumentally determined".

Three conditions, said Howells, were necessary in putting this hypothesis to the test:-

1. Different receptors of the subjects would be simultaneously stimulated by appropriate controlled stimuli.
2. The sensory functions involved must normally work together co-operatively in achieving a psychological end or goal, so that this end becomes the chief object of attention rather than the sensations themselves.
3. An unexpected conflict between these normally integrated (sensory) components should be introduced occasionally as a means of obtaining objective evidence of their normal synesthetic integration.

The ingeniousness of Howells' design grows as one reflects on his "basic conditions". The first one is straightforward enough: temporal contiguity is a sine qua non of all conditioning, indeed of virtually all learning. To contend that it is also a sufficient condition is what the associationists and their descendants have largely done — and some would say that Pavlov falls into this camp, but this is a vulgar error. The second condition is of primary significance. Although subjects would receive appropriate bi-modality stimulation and although the experiment becomes unviable unless this

is done, it is, Howells implies, almost absurd to make it the goal of the experiment. This is, of course, an indictment that could be levelled at so much of psychological - especially psychophysical - experimentation: the fact that self-consciousness intrudes in a way that confounds and even obliterates the original experimental objective. To obviate this requires a special kind of creativity, one that has to keep the experimenter at least a jump ahead of subjects who are becoming increasingly "maze-wise", especially as the work of psychologists becomes more and more widely disseminated among the lay public. We shall see in a moment how Howells attempted to circumvent this hazard and, still later, we shall have to assess the justification of his ploy. Finally, what seems at first glance a perversely incongruous condition turns out to be one of the most important and ingenious of them all. At this point Howells contents himself with saying that the occasional "unexpected conflict" between the normal stimulus-coupling is intended merely to serve the purpose of assessing the synaesthetic effectiveness of the "inducing" stimulus. We may anticipate by saying that it also serves the essential purpose of ensuring that the subject does not "switch off" one of his input channels : if (the inducing) stimulus A, through modality 1, invariably accompanies stimulus B, through modality 2, then Q can correctly report on B by focussing only on A, and E's aims are accordingly subverted. The "occasional unexpected conflict" is a cornerstone in this unusual design. It ensures that since Q cannot infer B from A, he has to pay close attention at least to B--even though, paradoxically this activity (according to condition 2) will not be his overall aim. But to the extent that his motivation is to attend to B (and therefore, to some extent, to A, since they are contemporaneous) the "bond", to use a Hullian term, between his response to A and his response to B is strengthened. But to the extent that it is strengthened, it will serve to produce "errors" when the "occasional unexpected conflict" occurs, and if E makes this, as Howells did, what Q has to avoid, Q is caught in a vicious circle of trying to avoid something by doing (namely paying closer attention) that which he cannot avoid doing. It is beautifully conceived design, and it also seems an infallible one.

But there is a fourth condition, which Howells acted on but does not specifically mention here, and that is: Q must be kept in

ignorance of E's aims. Must he? Why should this be? If we are dealing with conditioning then surely the more "basic" processes involved in this phenomenon cannot easily be blocked by the "higher" cognitive functions. But perhaps conditioning is only really effective when self-conscious events do not intrude. There is a pitfall here: Howells' fourth condition conflicts with his third, and therefore with his second.

Let us be more specific. A,1 usually accompanies (and is intended to induce) B,2; while C,1 usually accompanies (and is intended to induce) D,2. But occasionally A,1 is coupled with D,2 and C,1 is coupled with B,2. So far we have taken care of conditions 1 and 3. To satisfy condition 2, we tell Q that his task is to make as few errors as possible and that if he makes too many errors he will suffer some unpleasant consequence. Unless he is a very naive subject, the nett result of this is that both conditions 2 and 3 are vitiated: he has to attend to the stimuli per se, and his mistakes serve to indicate the nature of the trap that E has set for him. What we have here, in fact, is a game (which many would claim applies to nearly every psychological experiment involving concealment of E's aims) with pitfalls and binds for both E and Q.

Consider E's binds, for example. He tells Q (as Howells did), "If you don't come up to scratch (i.e. if you make too many errors) I'll sack you". E knows that his impecunious subjects need the money, but E also needs his subjects. His threats are idle but he has to pretend that they are not. On the other hand, E actually wants Q to make more and more mistakes (since these are taken as the index of the growth of synaesthesia) and if Q does make more mistakes, E should, strictly speaking, sack him. When Q sees that E not only does not sack him but in fact seems to regard him (so various subtle cues must surely serve to inform him) as the goose that lays the golden eggs, the game is really on. E's ploys can then be countered by Q in several ways: (1) He can make careless mistakes, i.e. he merely goes through the motions of playing the game according to E's rules, but is in fact playing his own game, knowing (or banking on the fact) that E won't call his bluff, because errors are what E really wants. (2) He can play the game on E's level, having seen through E's ploy. His self-instruction is a simple one: "ignore the inducing stimuli; they are of no consequence whatever; regard them as noise; respond

only to the real signals". The question now becomes, can Q do this? And if so, for how long can he keep it up? We shall see that these are important empirical questions. (3) He can oscillate between (1) and (2) and really confuse E as to what is happening.

Before the reader himself becomes too confused by the variety of ingredients in this Machiavellian pie, let us see what Howells actually did, what results he got, and how he interpreted them.

His subjects were eight university students who were paid by the National Youth Administration (the nature and function of which institution is unknown to me). None of them had taken courses in psychology, but they were required to act as both E and Q in alternate 20-minute stints; so condition 4 (keeping them in ignorance of E's aims) seemed to have a slim chance of surviving. Their task was to identify the colour of a light source as one or other of two complementary hues, a red and a blue-green. The test patch was the ground-glass screen (13 cm x 19 cm) of a simple colour-mixer and the stimuli were presented in two forms, highly saturated (no admixture of the complementary) and highly unsaturated, which Howells describes as "very diluted or pale, but readily recognized and named as reddish or greenish" by several control subjects. (Howells, it may be noted, was even more innocent of colour metrics than I am, and it is not difficult to imagine a colour scientist scoffing at the absence of technical know-how in his report. It would be a pity if this is the kind of reaction that has in fact occurred. Howells chose to work with colours and sounds because "coloured hearing" was probably the most frequently cited example of naturally occurring synaesthesia, not because he was interested in the science of colour. This by itself—even if his results were to have turned out to be quite negative—does not render his experiment irrelevant to our understanding of the basic processes underlying colour perception.)

Preceding and overlapping the presentation of each visual stimulus were one of two "distinct, characteristic" notes coming from organ pipes, a Middle C (261 Hz) and the G above (392 Hz). We are not told at what intensity the auditory stimuli were presented and this parameter (cf. Hull's stimulus intensity dynamism) could be of great importance if Q were to attempt to "ignore" the sounds.

The contingencies were as follows.

For the first 5000 trials, the colours presented were a saturated red (R) and a saturated blue-green (G). These were paired with the low and high tones (L & H) according to the schedule, LR and HG on 95% of the trials, and HR and LG on 5% of the trials. LR and HG thus constituted the "practice" or "conditioning" trials, while HR and LG were the "test trials", what Howells had previously referred to as the "occasional unexpected conflict". The presentation was randomized, several predetermined orders being used to prevent familiarization. The duration of the tone preceding the colour was less than one second, while the duration of the coincident colour-plus-tone was slightly longer than one second. (Howells is vague about the time-relationships. Apparently his E's had to manipulate both the colour-mixer and the organ-pipes without benefit of timers or programmers. For example, he says that the interval between successive trials was about five seconds and he also tells us that two subjects working together, alternating in the capacity of E and O, completed the first 5000 trials in 12 hours, i.e. 6 hours each. Now, if each trial took 7 seconds overall, 5000 trials should be completed in 9.72 hours nett, i.e. not inclusive of turn-around time, breaks, etc. Furthermore, we are not given any information on how long the rest of the experiment took).

The work was carried out in a darkroom. O kept his eyes shut between trials (presumably to prevent him from observing E's manipulations). The colour-mixer luminance was approximately 2 foot-candles. O was seated about 6 feet away from the screen, the angle of subtense being about $4^{\circ} \times 6^{\circ}$.

After five practice trials, which included the presentation of all combinations of colours and tones, each new O was told:-

- (1) that there would be a long series of such trials;
- (2) that the showing of red and green would be in irregular or random order;
- (3) that in some cases the colour would be more intense than in others;

(4) that while certain tones would usually precede certain colours, this would not always be the case and that he should be on his guard for exceptions in order to avoid making mistakes in his judgements; and;

(5) that his success in his work, and perhaps in keeping his job, depended upon making as few mistakes as possible.

As soon as the tone/colour stimuli ceased, Q reported the colour, closed his eyes, and waited for the next trial. E immediately reported success or failure to Q by the words right or wrong.

Subjects alternated in their role of E and Q every 20 minutes in an attempt to minimise fatigue and boredom, "usually over a two to three-hour period".

After the first 5000 trials (which included only saturated colours) the colour presented on every alternate trial was unsaturated, i.e. if on one trial the colour was R or G, on the next it would be r or g with the same ratios of pairings with L (low tone) and H (high tone) being maintained as before.

These trials were continued until subjects A and B had completed a total of about 32,000 trials each; subject C about 23,500 trials; D about 24,000 trials; E & F about 26,000 trials each; and G & H about 29,000 trials each. The eight subjects between them thus completed about 221,500 trials, which (on the basis of 7 seconds per trial) must have taken about 430 hours of nett working time, or (on the basis of 6 hours per 5000 trials) some 265 hours. We are not told how many days were needed to complete the experiment for each subject nor for the series as a whole.

Figure 1 is a reproduction of the curves showing errors made by each of the eight subjects as well as a composite error curve for all subjects. From these curves one can get an idea of the relationship between number of errors and number of trials; also, between errors and number of 'test' or 'reversed' trials. The number of errors shown by points on the graph is the number made during a period of 1000 'practices' or 50 'tests'. Howells says: "Practically all of the errors occurred on the tests and no others were counted". Most subjects show a spurt of errors at the outset of the second phase of the experiment, when unsaturated colours were first introduced. These errors diminish soon afterwards, but in no case to the level

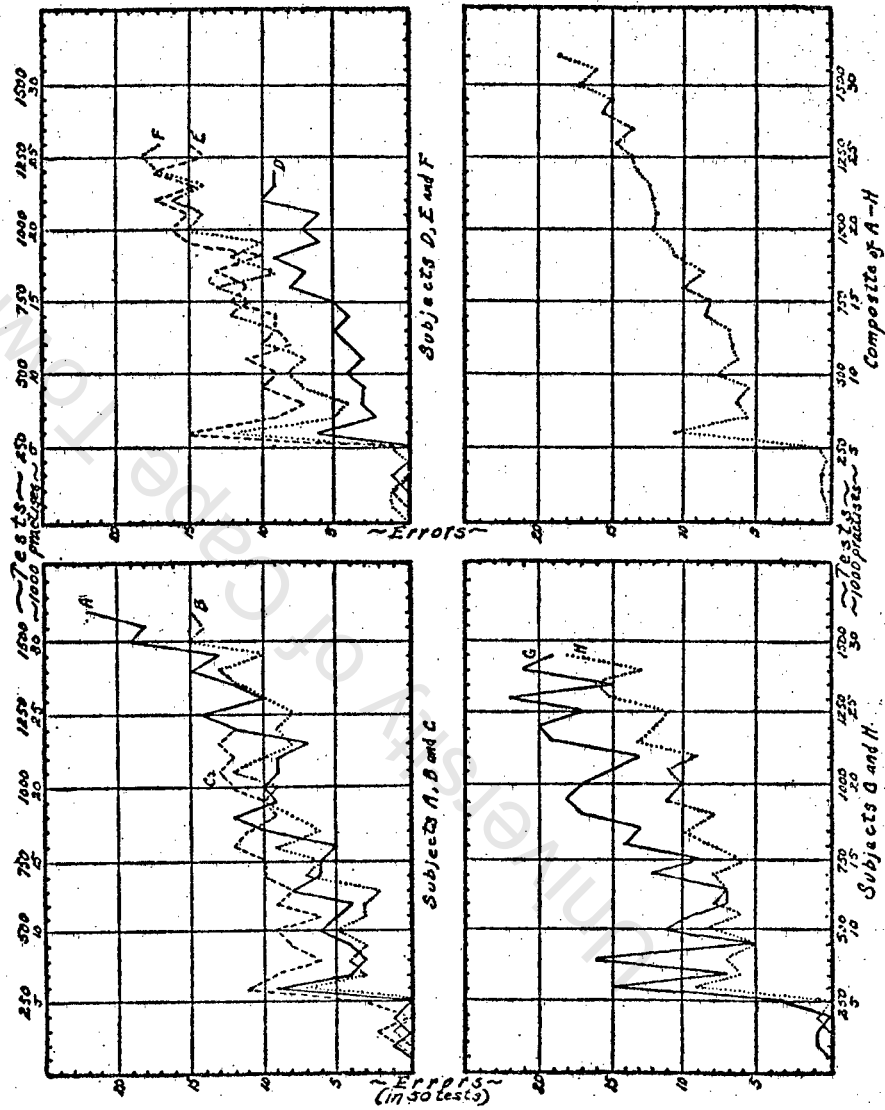


FIG. 1. Error curves.

Reproduction of error curves for 8 subjects from Howells (1944)

prevailing prior to the 5000th trial. As the trials continue, there is a general tendency for errors to increase more or less gradually. The composite curve shows a marked linearity. It will be noted from this curve that at the 30,000th trial the average error rate was about 17 in every 50 test ('reversed') trials, or nearly 35%, compared to an average of about 1% during the first phase, and about a minimum of 12% after this phase.

The important question is: what do these errors mean? Howells' interpretation is as follows.

The first sudden increase is attributed to the relative indeterminacy of the unsaturated colours compared to saturated colours with which they were alternated.

The Qs became disoriented in their color judgements and, of necessity, were compelled to rely very largely upon the indicator tones, which were of course misleading in the test trials. The Qs very naturally knew that test trials were interspersed with the others, and their suspicion undoubtedly persuaded them to disagree with the misleading indicator tones on some of the tests, which perhaps reduced recorded errors to some extent, but it also led them to disagree when the indicator tones were right and, therefore, to make errors which do not show in the curves. For these reasons, therefore, the curves probably do not represent the actual extent of failure to discriminate the colors.

(Howells, 1944) (Emphasis added)

Another important observation which Howells makes is also worth quoting in full:

The Q's generally reported a general lack of confidence in their judgments when the paler colours were introduced. In some of the tests however, they reported more confidence than in others, and apparently their judgments on these tests were more often correct. For some reason, perhaps involving momentary distraction of attention, disorientation, or some other accidental factor, the indicator tones were much more disturbing for some tests than in others, and the perceptions of color were more uncertain in some practises than in others. On the whole, however, the number of errors in judgments seemed to constitute a good measure of actual perceptual interference.

(Emphasis added)

3.3 Howells' Study

How does Howells explain what is probably the most interesting part of his error curves, the steady increase after the initial rise and fall?

The only possible explanation of this continuous increase in errors seems to be that it is evidence of cumulative conditioning by which the substitute tonal stimulus was gradually strengthened by further association with the stronger or saturated color-stimuli, until it was able to dominate and reverse perception of the weaker color-stimulus in an increasing proportion of the tests. The habitual set, or expectancy of seeing a given hue after hearing the paired tone, became so strong that it overpowered the conflicting perceptual influence of the hue actually supplied, with the result that pale green was actually seen as pale red, or vice versa.

(Emphasis added)

Howells mentioned that it would have been worth while to continue with the conditioning process beyond the point at which each of the subjects stopped "but limitations in available time of the Qs made this impossible".

General observation of the behavior of the Qs near the end of their period of service indicated to the writer that their errors probably would have continued to increase, perhaps at an increased rate if they had continued with the practices. They seemed to develop nervousness as their errors increased and showed a disinclination to go on with the experiment. Two out of the eight (A and G), at least, became uncertain and erratic in making their decisions and changed them so often that it was difficult to record them with certainty. One or two of the others seemed to become indifferent and apparently made decisions more or less at random without much attention to the colors. One of the Qs (A) showed symptoms of incipient behavioral disorganisation, failed to keep appointments, and tried to transfer to another job at a sacrifice of regularity and convenience in hours. Although most of the Qs said they preferred to act as observers during the first part of the experiment, they all preferred the job of serving as experimenter during the latter part of it. They reported that sitting as an observer was more tiresome, and also that it made them 'jumpy'.

Actually the impression of the writer was that unwittingly the experiment had achieved about as much success in developing neurosis as in creating synesthesia.

(Emphasis added)

Howells very properly goes on to deal with other possible interpretations of these results.

There is perhaps some justification for considering whether or not the conditioned response to the tonal stimulus was not primarily a verbal response rather than a perceptual response; that is, that the Qs were directly conditioned to say the word red, for instance, rather than that the word was a report of what they actually saw. There is no reason to doubt that conditioning did facilitate saying the words most frequently associated with the tones. The Qs did show a tendency at times toward speaking the associated word thoughtlessly or mechanically as soon as the tone was sounded. It is very probable that this tendency was responsible for some of the errors, especially in the early part of the experiment. The automatic corrective for such impulsive responses, however, was the fact that they resulted in making mistakes which the Qs very much wanted to avoid. They soon learned to be on their guard against making such rash judgements and, as previously mentioned, four of them spontaneously developed the practice of waiting for a brief time after both stimuli had ceased before making their judgements, partly at least because they believed that the color image cleared up and became more dependable by that time. The manner of the Qs in making their verbal reports also tended to give the impression that in most instances they were reports of actual visual observations rather than mere mechanical observations.

Still, it cannot be denied that the conditioned verbal response was actually part of the total organismic response, and undoubtedly contributed its share in determining decisions about color. One of the Qs reported that, even after deliberate delay of his report, the word indicated by the tone still 'trembled on the tip of my tongue'. Perhaps the best interpretation is that the verbal response was as much a means by which the perception was mediated as was the word a resultant of the perception.

(Emphasis added)

We now come to the part of Howells' experiment which Taylor (1958) regards as "among the most important in the history of psychology".

In the hope of testing the hypothesis that the supposed synesthetic effect was merely a conditioned verbal response to a tonal stimulus, that the supposed distortions of color perception were perhaps merely slips of the tongue, an additional test was devised and given to two of the Qs (G and H) when they had nearly finished their part in the experiment.

They were trained to use an extension rod to operate the slide on the chromatoscope [colour-mixer] so as to adjust it for what appeared to them to be a point neutral between the two colors, or the best possible white, moving in on one trial from bright red [sic] toward the green, and on the next from bright green [sic] toward the red, in alternating order. After each adjustment was made, a reading of the scale of the chromatoscope was taken. When the Qs had attained some degree of efficiency, the exercise was continued as before, but now one or the other of the tones to which they had previously been conditioned was sounded quite continuously all the while they were adjusting the chromatoscope for white. A scale reading for such adjustment was made and recorded, and then another adjustment was made starting with the other color, and perhaps with the other tone sounding. Adjustments were made alternately, starting with different colors, but the high and low tones were sounded in random order. One hundred readings were made for each of the two Qs.

Frequency distributions of readings of the scale of the chromatoscope were made, one while the lower tone, C, was sounded, and one while the higher tone, G, was sounded. The mean scale value for 100 combined readings with the lower (red) tone was 4.64, and was displaced from the point of adjustment for white (5.00) toward the green, indicating apparently that additional green was needed to compensate for the coloring effect of the lower (red) tone. The mean scale value for 100 readings with the higher (green) tone sounding was 5.42. The difference between the means was .78, and the standard error of the difference in the means was .19, affording a critical ratio of 4.1. This seems to constitute reasonable proof that the tones actually exerted a coloring influence upon the visual perceptions, independently of any verbal response.

Howells performed certain other tests, all of which afforded him convincing evidence that a genuine tone-contingent shift in hue perception had occurred as a result of the verbal conditioning procedure.

This concludes a necessarily lengthy account of Howells' (1944) paper, "The Experimental Development of Color-Tone Synesthesia."

Since it is only because of Taylor's (1958; 1962, p.246-247) accounts of this experiment and the importance he attached to it as a demonstration of the role of language in the development of colour-perception that I had decided to focus attention more minutely on what exactly Howells achieved, I shall not proceed with the discussion it warrants until I have dealt with (a) Taylor's own views, and (b) attempts by students in this Department to replicate Howells' findings. I shall then describe my own experiments which, though inspired by the paradigm suggested by Howells and more explicitly spelled out by Taylor, were not strictly replications, since they employed a rather different overall strategy, with a modified set of contingencies.

Only after my own results have been presented and interpreted will it be expedient to return to Howells. To do otherwise would possibly convey a measure of perspicacity that was not in fact achieved until a very great deal of effort and thought had been expended on the subject.

3.4 Taylor's Evaluation of the Howells Study

Taylor's first (1958) mention of Howells did not arise in the context of colour *per se*. In a paper devoted to a stinging attack on certain tendencies in current psychological research, Taylor refers to W. Ross Ashby's notion of ultrastability and cites Howells' study as one of a small but important body of experimentation involving the human organism considered as an ultrastable system. Whether Howells' work clearly falls into the category of "the manipulation of variables in such a manner as to throw the system out of balance, temporarily destroying its stability", as Taylor implies in this paper, is a matter which we shall have to debate in due course. "If the system is ... part of an organic system and therefore ultrastable, it should adjust itself to the experimentally altered conditions and correct the induced instability". Applying this principle to perception, he hypothesizes that "perceptual stability is a direct function of the behavioural stability which the organism achieves automatically through learning".

Taylor comments as follows on the experiment:-

[In the following quotation I shall not use Taylor's notation, but rather the one I have adopted myself, namely,

R = saturated red
G = saturated green
r = unsaturated red
g = unsaturated green
L = low tone
H = high tone]

It is easy to see that in this situation the verbal response 'red' became conditioned to L, and 'green' to H, so that LG and HR ultimately tended to evoke the responses 'red' and 'green' respectively. Learning theory enables us to deduce that the number of erroneous responses to Lg and Hr and even

to LG and HR must have increased progressively, since drive was increased as the tally of errors mounted, resulting in larger increments of habit strength each time a correct response was given to LR, Lr, HG or Hg.

The results reported by Howells are in fact entirely explainable in terms of learning theory.

Howells completed his excellent study by performing two experiments which he modestly describes as supplementary but which are in fact among the most important experiments in the history of psychology. I shall describe only one of them. The apparatus for producing the chromatic stimuli was modified so that the subjects themselves could alter the proportions of red and green light reaching the ground glass screen on which the colours appeared. At the beginning of each trial the apparatus was set by the experimenter so as to produce either R or G, and the subject was required to manipulate the control until the light appeared to him to be neutral. If this was done to the accompaniment of the low tone the light which the subject saw as white was invariably an unsaturated green; with the high tone it was an unsaturated red. That is, the conditioning of colour naming responses to the tonal stimuli had changed the colour perceptions of the subjects.

(Taylor, 1958)

(Original emphasis)

Taylor goes on to deal with a possible objection, namely that his conclusion is not justified in the absence of a control experiment in which no new responses of any kind were conditioned to the tonal stimuli.

As it happens, the required control was supplied earlier by Kelly (1934) who, oddly enough, described the technique he employed as that of the conditioned response. Actually, what he did was to present certain pairs of tonal and chromatic stimuli a large number of times but without asking his subjects to do anything except attend to them. Since the experimental situation did not provide for the reinforcement of any responses the subjects might make, there was no conditioning of any kind. Consequently, if the changes in colour perception reported by Howells had nothing to do with the conditioning of colour naming responses but were entirely due to the repeated conjunction of one tonal stimulus with one chromatic stimulus, exactly the same kind of results should have been obtained by Kelly. In fact his results were uniformly negative.

(Taylor, 1958)

Taylor's next reference to Howells occurs in the chapter devoted to the perception of colour in his (1962) book, "The Behavioral Basis of Perception". In dealing with the "natural situations that provide occasions for the conditioning of selective responses to the wave composition of the light", he says:

There is one important source of refinement of color discrimination that is available to man and to no other species. This is language. It is unlikely that language is ever the medium through which color is created for the first time, since the child normally acquires selective responses to food and to other objects and substances in his environment while his command of language is still quite primitive; but language is unexampled as a means of subdividing the relatively small number of wide ranging equivalence classes that are established through interaction with the natural environment.

(Taylor, 1962, p.246)

(Emphasis added)

It is important to note that in both places Taylor regarded the central aspect of the "Howells-effect" as illustrating the role of language in colour not merely as a labelling device but as a means of developing new kinds of constancies or equivalence classes or transformations:-

The manner in which language operates may be gathered from a beautiful experiment reported by Howells in 1944 ... [in which] the response of naming red became conditioned to the low note, and that of naming green to the high note ... But the subjects actually saw red as green or green as red, and this was conclusively proved by a supplementary experiment in which the subjects were asked to adjust the filters so as to make the color change from its initial R or G to white. If the adjustment was made to the accompaniment of the low note, the light which the subject declared to be white was actually an unsaturated green. If the high note was sounded during the adjustment, the color that to the subject looked white was an unsaturated red,

(Taylor, 1962, p.246)

(Emphasis added)

He concludes by saying that "what determines the perceptual outcome is not the stimulus but the activity of the engram mediating the response conditioned to it". For example, in the adjustment of the colour-mixer while the low note was sounding, the fact that what was green "by normal standards" was seen by the subject as white is interpreted as meaning that an "engram was operating to push the perception in the direction of red".

We may perhaps describe the action of this engram by saying that it delivers to the motor system an instruction of the form: Act as if red has been added to the light. The engram is still active when the adjustment has been made, but there is no evidence of the overt response in the subjects verbal behaviour.

It will be seen that in this respect the perception of color has the same formal properties as the perception of space. This is, the building up of a stable behavioral field is a necessary condition for the emergence of perception, but it is the activity of the engrams that constitutes perception and not the actual performance of the responses.

(Taylor, 1962, p.247)

The next series of experiments to be mentioned were prompted by Taylor's own enthusiastic reactions.

3.5 Attempts to Reproduce the "Howells-effect"

The first was my attempt (Abramovitz, 1962) as a graduate student under the supervision of Dr. Taylor himself to use the Howells technique to condition subjects to make responses of "sweet" and "salty" to water containing tasteless red and blue dyes; these solutions having previously contained cane sugar and sodium chloride respectively. The verbal conditioning was partially successful, at least with one subject, but the results of post-experimental tests to determine whether a hue-contingent shift in gustatory perception had occurred were equivocal.

The first attempt to replicate the Howells-effect with tones and colours in this Department was that of Sylvia Hutton (1970), then a graduate student working under my own supervision. Some changes in the experimental parameters were made, chief of which was the introduction of a second conflict-evoking contingency. Inspired by the Stroop Colour-Word Test, the conditioning trials were such that I responded (for example) to a green-illuminated outline of the word "GREEN" while a high tone was sounded, whereas in a "double-reversed trial", he saw a green-illuminated outline of the word "BLUE" while a low tone was sounded. The unexpected result, after 11,000 trials were completed by each of the two experimenter-subjects, was that not even any significant verbal conditioning could be elicited.

In this experiment the most important deviations from the Howells parameters were considered to be (a) the use of sophisticated post-graduate psychology students who were not only aware of the aim of the experiment but were actually instructed to "resist" the process of conditioning, and (b) the presentation of the chromatic stimuli at too high a luminance level which may, in part, have been responsible for certain prolonged fatigue-like shifts in the perception of unsaturated blue and green towards pale yellow and pale mauve respectively, irrespective of tone or word contingencies. (These after-effects were no ordinary variety of physiological "bleaching". In one case they lasted for at least two weeks. A control experiment by Silke Vogelmann (1971) revealed the surprising result that merely looking at the same visual stimuli for the same number of trials over the same period did not elicit the phenomenon).

The next attempt was that of Gilbert (1971), an undergraduate student also under my supervision, who programmed a small on-line computer to present the stimuli, monitor Q's responses, provide him with appropriate feedback signals and give E summary statistics at the end of each session in terms of number and kind of errors as well as reaction-time means and SDs to the nearest millisecond. Changes from the Howells procedure were:-

- (a) Use of unpaid (undergraduate) female psychology students who were instructed to read and digest Howells' paper but were not told to resist the conditioning process,
- (b) Instead of saying "red" or "green", the subject was told to press one of two keys on a table in front of her,
- (c) Instead of an open-field presentation of low or high tones, they were presented, binaurally, via headphones.

After 15,000 trials were completed by each subject there were no increases in errors of the kind that Howells reported (after the initial settling down in the region of trials 6,000-8,000), although in the case of one subject the error rate at the end of the experiment was equivalent to that shown in Howells' "composite" curve. These errors were going down, however, not up. No tone-contingent hue-shift was obtained. The two subjects were both extremely bored, rather than disturbed, by the experiment, and in each case refused to carry on after trial number 15,150.

Silke Vogelmann (1971, 1972) performed some very carefully designed and executed experiments eventually achieving a measure of success. In one series, she was concerned with the role of Q's awareness of E's aims in producing the Howells-effect and concluded that "a knowledge of the contingencies helped the Qs to counteract the influence of the tones so that no conditioning of verbal behaviour was achieved". Only one subject in the "unaware group" showed a rise in error-rate comparable to that obtained by Howells but no evidence of a tone-contingent hue shift was obtained. In another series she adopted the interesting strategy of delivering a consistent positive reinforcement to her subjects when they made the "desired" colour-naming response contingent on the relevant tonal stimulus. In other words she employed a Skinnerian shaping technique to change the verbal behaviour that was presumed to mediate the colour experiences.

What was required here, in addition to the saturated colours, Vogelmann argued, was a finely graduated series of unsaturated hues ranging from UG to UR and passing through Q's confusion range. By judiciously pairing the tones with colours of increasing chromaticness it was hoped to achieve not only a naming operant of 'red' to L and 'green' to H, but a corresponding perceptual modification.

The results of this experiment were the first hint of a breakthrough in replicating Howells' phenomena. Two subjects were used, both psychology students, who were kept as ignorant as possible of the nature of the experiment. Vogelmann (1971) reports as follows:-

Subject S [male] definitely did not become conditioned to the tone and did not realise their significance...

Subject M [female] writes, after completing 4,896 trials: "Low tone connected with red, high tone with green. This dawned on me quite suddenly. I had found myself 'singing' my responses either high or low-pitched in accordance with the tone... from then on I answered according to the tone, being reinforced by the 'ding-dong' [door chimes used as a positive feedback signal]! The advent of the tone prepares one as it occurs before the onset of the light--thus I am beginning to see what I expected to see and I am giving responses which I would have thought were

wrong, before my realising the connection between the tones and colours. With some panels [referring to the colour-mixer screen] which I had previously seen as one [homogeneous] colour I now see patches of the 'correct' colour appearing... I see green, but because it occurs with a low tone it loses some of its greenness now and patches of red appear in it. Sometimes in the centre of the panel, sometimes framing the panel".

Subject M wrote after her first post-test (after 8,496 trials):- "cannot recognize ANY neutral point. Both colours ALWAYS present. Adjusting from green with the low tone causes flooding of the green panel with red. Colours during adjustment with the tone are represented in stripes either horizontally or set at 45° from left to right. Adjusting to the high tone is not as difficult as to the low tone. No neutral point is found.

Adjusting without the tone is easier. Colours are more controllable, i.e. do not mix in stripes but homogeneously."

(Vogelmann, 1971, p.119)

Vogelmann then made a very revealing observation. Subject M mentioned that during the trials she had reported that she saw red, for example, but in fact said 'green' because it was reinforced, and vice versa. "When it came to the post-experimental test of perception this subject asked whether she should answer 'to the tones' or to what she sees."!

She was instructed to answer according to her perception [of the colour]...[and]...it was noticed by E that she did not respond to the tones on a large number of trials. She reported on this test: "I was told to disregard the tones and report only what I saw—this was extremely difficult and the tones had a measurable effect on my perceptions. On hearing the tones...I expected to see the corresponding colour. I realised that often, although the panel was one colour, I was superimposing the expected colour like a thin film and would then SEE it in that colour. I did not once perceive a neutral panel, though in a pre-test one week earlier...I had perceived neutral colours. Panels appeared mostly bi-coloured. When they were presented without the tone, decision on their true colour was fortuitous. When presented with tone, decision was easier, as I then 'knew' what was coming and 'saw' accordingly."

On the post-test with adjustment for neutral point, she wrote: "The most startling fact was that I did not see a neutral point... not one panel was free of colour... both colours were present and establishing a neutral point was finding a point where the amounts of each colour were equal in the panel. This was easier when no tone was presented, as the colours remained pretty stable during adjustment, i.e. it was easier to control their amounts by turning the dial. When the adjustment was presented with a tone, the colours were 'restless' and in motion. The low tone especially had this effect... it produced visions of red colour which would cloud over the panel after about 15 seconds. This effect was less marked with the high tone, even though both colours in the panel were unnoticed during adjustment. However, there was no clouding effect as with the low tone and no 'flooding' of the associated colour into the panel."

(Vogelmann, 1971, p.120)

I have quoted Vogelmann's report at considerable length because to her goes the credit of being the first to elicit phenomena which appear excitingly like those that Howells spoke of. That the issue still remained incompletely resolved, however, is evident from the succeeding parts of her account:-

Subject M's final remarks are very interesting: "I feel in further experimentation in this field it would be necessary to use completely naive subjects, as I feel a person familiar with psychological concepts, experimental designs and methods will experience the experiment [sic] in a different way... this was demonstrated to me clearly when I... realised that the tones were connected with the colours... Reinforced by the 'ding-dong', my pattern of responding changed and I felt myself 'working' to see the colours as I was 'supposed' to, according to the tones, maybe in an effort to convince myself that there was no discrepancy and that I had been seeing the wrong colour."

(Vogelmann, 1971, p.120)

This subject, in post-experimental tests showed statistically significant tone-contingent shifts in hue-responses, but what remained undetermined were (a) whether these were genuine and stable perceptual after-effects, (b) whether they were the result of some form of "compliance", given Q's quoted observations, and (c) the

size of the shift or modification, granted the statistical significance of the tone-contingent differences. As Vogelmann (1971, p.126) points out, "As the verbal response was NOT a conditioned response in the sense that the response was emitted automatically or involuntarily, the effect may be due to autosuggestion [sic]. Whether positive evidence is provided for Taylor's hypothesis by subject M's performance is debatable."

Essentially, the problem that Vogelmann's experiment presents us with is how to interpret the reactions of a subject who, knowing what she was supposed to say, could not decide whether what she saw was what was there, or was merely what she realised she ought to say was there. And it seems that this was not a simple experimenter-effect. It really does seem as though she had a genuine internal conflict and is as powerless to resolve it for herself as for us.

This, then, completes an account of the attempts in this Department to reproduce the Howells-effect prior to my own onslaught on the problem.

3.6 Recapitulation and Appraisal

Before embarking on the very complex series of experiments (involving nine subjects) which I undertook, it is necessary to recapitulate and review everything that has been said since Howells' own report was presented. The problem here is to guard against anachronistically inserting "hindsight comments". I shall endeavour to give the reader as accurate an account as I can of my reactions to the problem prior to the empirical evidence which I was myself able to glean.

To proceed in stages, I shall pin-point some critical issues which the Howells report raises, then comment on Taylor's reactions to Howells and, finally, in the light of this discussion, sum up the implications of the largely negative results obtained by Hutton and Gilbert, and the equivocal ones of Vogelmann.

The first issue I wish to raise concerns an assertion by Howells that in Kelly's (1934) attempt to produce "artificial chromaesthesia", despite the fact that "paired presentations were apparently continued for a long enough time to achieve positive results if they were at all possible, no success was obtained." By this is implied (and the reader who does not go directly to the Kelly paper will surely provide corroboration) that Kelly went on for at least as long as Howells in terms of either number of trials or hours of conditioning. In fact, Kelly's 36 subjects completed between 360 and 2000 trials each, averaging 996 each overall, while Kelly himself was the only one to complete more than two thousand trials (3000 to be exact). So we have Kelly's 36 subjects completing a total of 35,840 trials as against Howells' 8 subjects completing a total of 221,500 trials. To represent Kelly's (quantitatively) quite puny effort as comparable or even commensurable with his own Herculean labours is patently absurd. It

is certain that after 1000 trials (given a scaled-down version of the experiment) Howells' findings would have been just as negative as Kelly's. And who can say what results Kelly might not have achieved had his subjects gone on to complete say, 30,000 trials? Whatever the flaws in Kelly's design, and Howells' criticisms are convincing in this regard, the parameter of sheer volume of iteration cannot, and must not, be ignored.

But there is another difference between Kelly's and Howells' designs which by itself would have rendered their respective findings incommensurable. Kelly's subjects were mainly graduate students in psychology who were told in fairly precise terms what E's experimental objectives were. Howells' subjects had not undertaken any courses in psychology and were kept "as ignorant as possible" of the aims of the experiment. Nowhere does Howells mention this difference.

The next point is one that Hutton (1970) and Vogelmann (1971) were themselves quick to point out. Howells does not include in his data errors made on conditioning (non-reversed) trials. It is not enough for him to say, "Practically all of the errors occurred on the tests". That he realises this himself is revealed in a later passage when he says that

The Qs very naturally knew that test trials were interspersed with the others, and their suspicion undoubtedly persuaded them to disagree with the misleading indicator tones on some of the tests, which perhaps reduced recorded errors to some extent, but it also led them to disagree when the indicator tones were right and therefore to make errors which do not show in the curves."

(Howells, 1944)

(Emphasis added)

This point is quite crucial. It may have been the case that his subjects in his experiments perpetrated most of their errors on reversed trials, but in the absence of a comparison with errors on non-reversed trials, we have every right to be sceptical of the blanket "explanation" of the cumulation of errors as an unequivocal index of reversals in hue perception. When Howells actually goes on to say that near the end of the experiment "One or two [of the Qs] seemed to become indifferent and apparently made decisions more or less at random without much attention to the colors," scepticism gives way to disquiet.

"Actually the impression of the writer was that unwittingly the experiment had achieved about as much success in developing neurosis as in creating synesthesia". The theoretical implications of this phenomenon are open to debate. Is experimental neurosis a necessary concomitant of experimental synaesthesia? Does Howells' model embody the notion of disruption or disorganization of behaviour and therefore of perception? We are not treated to any discussion concerning the (theoretical) possibility of producing a functional synaesthesia in the absence of an overall disturbance. Certainly, there was no way of deducing, from the three conditions he laid down, that neurotic reactions were bound to occur.

And since they did occur, we are further troubled by whether the perceptual changes were not, in part at least, a function of these other changes, and not a simple conditioning effect as, say, conditioning the eye-blink to a tonal stimulus is usually taken to be.

Howells himself realised the need for subsidiary tests to vindicate his assertion that the error increases were the result of, or at least an index of, tone-contingent perceptual changes, and if his subjects, outside the harassing experimental situation, manifested such changes in a manner that was both statistically and psychologically significant our unease on this point would to some extent be allayed.

The first, and most important, of these tests was undoubtedly the method of adjustment whereby, under the influence of the low and high tones respectively, subjects neutral settings were said to be pushed towards green and red.

The first question that must occur to anyone reading this part of Howells' report is: why was the test applied to only two of the eight subjects (G and H)? Was it because they showed a far greater rise in error-rate than the others? A careful inspection of Howells' error curves (Fig. 1, p.53) hardly bears this out. Judging by both the slope and terminal value of these curves, the only subject that might be excluded on these grounds is D. But is there any warrant to exclude any subject from this most important procedure? Surely, the hypothesis that increase in error-rate is an index of an increasing tone-contingent perceptual change must be tested on all subjects, so

that it can be shown that those subjects (like D) whose rate of increase as well as absolute number of errors, is relatively small, display little if any modifications in perception compared to, say, A, F, G and H.

We are simply not told why only two subjects were selected, nor are there any indications in the report that allow us to correlate, even vaguely, individual error-rate with size of perceptual shift.

As to the manner in which the test itself is carried out and the results analysed, the reader is invited to re-inspect Howells' own account (p.57) and reflect on its import. We shall return to this part of the experiment on more than one occasion. For reasons that will become clear, nothing further will be said now.

Finally, and in many ways this is the most important question I wish to pose: how did Howells manage to keep his subjects believing they would be discharged if they made too many errors? This question will take on added significance when the Cape Town data are evaluated. For the moment, let us remember that Howells first presented his results in the form of an abstract in the Journal of Experimental Psychology as early as 1937. A panel of experts in social and economic history might throw light on the conditions prevailing in Boulder, Colorado in the thirties. Perhaps these conditions were such that, if you offered your student-subject good money provided he gave satisfaction, he would sooner develop a neurosis (and see colours that "weren't there") than not give satisfaction.

But, from the subjects' point of view, to give satisfaction meant not to make more and more errors. (From E's vantage, of course, the opposite is true). It seems that the ploy mentioned before (p.49) that of simply ignoring the tonal stimuli completely, should work. Why did it not? Was the intensity (or other quality) of those organ notes so insidious, so impossible to withstand, after all? We shall probably never know for sure.

Howells' experiment was planned and executed on a heroic scale. That it should be subjected at all to this kind of nit-picking is an indignity. But laboratory experiments should be replicable; and experiments from which large-scale deductions are made (e.g. about the

nature of sensation and perception and their relation to language in particular, and organismic adjustment in general) should be executed and reported in such a way that failure to replicate is a function of incompetence in the would-be replicator, rather than possible negligence on the part of the original reporter.

We can turn now to Taylor's own gloss of the Howells report.

It will be recalled that Taylor introduced this "undeservedly neglected experiment" as the first example of "experimenting on an ultrastable system". Ashby's notion of ultrastability, we must bear in mind, is the dynamic property of an organism whereby, in response to repeated application of certain primary operations, it can "change the internal relations of some of its variables in such a manner that those primary operations no longer tend to throw it out of balance". It is, in other words, a self-regulating property whereby adaptation to an agency which initially produces a state of disequilibrium, eventually results in a fresh equilibrium. A paradigm case is adaptation to distorting spectacles, in which the initial behavioural and perceptual disruption eventually gives way to stability. To what extent, if at all, can Howells' subjects be seen to exemplify this property?

Certainly, when the unsaturated colours were first introduced there was marked disruption in behaviour, and presumably, in perception. We can go further. Howells states: "The Qs became disoriented in their color judgements and, of necessity, were compelled to rely very largely upon the indicator tones, which were of course misleading in the test trials". It is as if the subjects were attempting to "view" the unsaturated colours via the medium of the auditory modality, and here, of course, they came up against a built-in "distorting device". It could then be quite neatly argued that the general reduction of errors was a clear instance of ultrastability.

There are three objections to be raised against this view. The first is that none of the subjects showed a drop commensurate with their initial (pre-experimental) reactions to these pale colours, which, Howells reassured himself, were definitely supraliminal. True ultrastability, as in reinversion of the visual field on adaptation to inverting spectacles, should result in near-zero errors in all trials

Secondly, not only did the error-rate not stabilize itself at the (comparatively) lowered value, it continued to rise. Thirdly, in most cases a secondary behavioural disruption occurred, variously described as "nervousness", "disinclination to go on with the experiment", "erratic in making decisions" and "jumpiness", which in fact gave Howells the impression "that unwittingly the experiment had achieved about as much success in developing neurosis as in creating synesthesia".

Let us still try to save the situation and make out a case for ultrastability by looking at the results of the adjustment post-test with subjects G and H. Remembering Howells' own description of this procedure and its outcome, behold the words which Taylor uses: "... to the accompaniment of the low tone the light which the subject saw as white was invariably an unsaturated green; with the high tone it was an unsaturated red" (Taylor, 1958) (Emphasis added)

That Taylor has wildly exaggerated the extent of the Howells-effect, we can be in no doubt, even without performing a more elaborate statistical (and psychophysical) analysis than that given by Howells himself. It was not until my own findings prompted me to undertake a re-examination of these results that it became clear how weak (in psychophysical terms) the original Howells-effect was. I shall elaborate on this in the proper place.

A stable and significant change in the subjects' colour perceptions, under the influence of the tonal stimulus, might incline us to view the new equilibrium achieved as a special kind of ultrastability. Instead, what do we have? Out of the eight subjects, two manifested a quite marginal tone-contingent hue shift (on this critical test), whereas most of them exhibited considerable behavioural disequilibrium.

Finally, we note that Taylor repeats Howells' claim that Kelly's experiment constituted "a control experiment in which no new responses of any kind were conditioned to the tonal stimuli", without mentioning the differences in terms of (a) number of trials performed, and (b) subjects' awareness or unawareness of E's aims.

We go on now to a discussion of the failure in the Cape Town experiments reported thus far, to replicate Howells' results (with the possible exception reported by Vogelmann).

A common thread which runs through the experiments reported by Hutton (1970), Gilbert (1971) and, with qualifications, by Vogelmann (1971, 1972), is that, given a subject who is aware of the experimental objectives and contingencies, it is virtually impossible, using the original Howells paradigm, to produce any verbal (or motor) conditioning, let alone evoke a tone-contingent hue shift as an after-effect.

Just as Taylor (1962, p.247) described the Howells-effect by saying that the engram mediating the response conditioned to it "delivers to the motor system an instruction of the form: Act as if red has been added to the light", so we could describe the non-evocation of this effect by saying that there is another engram whose superordinate function is to deliver to the system an instruction of the form: act as if there is no tonal stimulus present! Why subjects in these experiments were able to ignore the tones so easily compared with Howells' subjects is not easy to explain. To answer that Howells' subjects were "kept as ignorant as possible of the aim and possible outcome of the experiment" is not convincing. After 20,000 trials as both "experimenters" and "observers", his subjects must surely have been astute enough to divine the general nature of the experimental objectives. Why, to repeat our former question, were they not able to do what the Cape Town subjects found so tediously simple?

In discussing their negative results, my own students were quick to point to the threat of dismissal as a stress factor which they were simply unable to introduce with any degree of verisimilitude.

Other "flaws" in the Howells design were mentioned, including the inadequacy of the method of adjustment as performed by him; but there is no need to labour them at this point. It became clear that a radically different attack on the problem was necessary, one which took Taylor's axioms seriously, and a fresh start was made along these lines in the series of my own experiments to be reported next.

3.7 A Fresh Attack on the Problem: Introductory

After nearly two years of virtually fruitless efforts by students in this Department to obtain a tone-contingent shift in hue perception as a function of conditioning, it became clear that a radical re-thinking of the whole problem was necessary. It should be borne in mind that the Cape Town experiments constituted no refutation of Taylor's hypothesis. They were simply inconclusive.

The first decision, therefore, was to abandon the idea of a mere replication of the Howells study. Taylor's axioms and the theory based on them had not as yet led to any new empirical research in colour perception. Yet his conceptions with regard to colour in particular and the modalities in general were so clear-cut and so apparently open to experimental attack, that a fresh start seemed imperative.

Stated simply, what seemed to be required was to design a situation in which the subject had to make the same response both to a given colour stimulus and a given tonal stimulus. At first glance this might seem anticlimactically inane. For one thing, was this not really the basic feature of the Howells design, even though it purported to require a discrimination rather than a generalization? This question is not easy to answer. A good deal has already been said about the paradoxes inherent in Howells' method. A more elaborate

theoretical discussion would not be fruitful at this juncture, but one salient point can be made. The task of Howells' subjects, unlike those who are asked to wear distorting spectacles, was relatively passive. True, they had to remain alert, but the mode of adaptation which was required of them was one of long-term endurance rather than problem-solving. In this respect it was more akin, as Howells himself says, to "the conflict situation of Pavlov's dogs, obliged to discriminate increasingly similar geometric patterns" than to an ultrastable system being thrown out of balance and through learning acquiring a new and relatively sturdy equilibrium.

What really beckoned to be exploited in this regard was the small but powerful on-line computer which Gilbert (1971) had programmed to replicate, as closely as possible, the Howells design. There seemed no obstacle (except lack of imagination) to designing an environment in which the subject had to find the solution to a puzzle which was of such a nature that in the very process of succeeding, rather than failing (as in Howells), he was obliged to make a common response to both a tone and a colour. Moreover, there was no reason, on Taylor's premises, why a subject who was fully aware of the aim of the experiment should not acquire a novel response-readiness which incorporated both sound and colour into a single equivalence class.

The basis of the computer-controlled puzzle environment is this. Let Q be seated at a table with two response keys, left and right. In front of him is a colour-mixer with a 3° square field. He wears headphones which allow for dichotic stimulation. There are various (acoustic) feedback signals available. He is told that the only way in which he can communicate with the computer is by key-pressing, but he is not told what his task is. He may be told which signals betoken negative and which positive feedback; what he must be told, at intervals, is his general level of performance or proficiency in "solving the puzzle", as reflected in whatever summary statistics E specifies should appear in the within-session computer printouts.

The emphasis is no longer on a mindlessly simple set of responses which Q is told to make, over a very protracted period. Q's wits are rather pitted against E's with the overriding proviso that, no matter what the exact form the puzzle may take, finding the correct solution (and maintaining a response rate at some criterion of speed and

accuracy) involves Q in making a unique response to stimuli belonging to two modalities.

The problem, to begin with, is E's. I shall briefly describe the nature of the puzzle that I presented to my own subjects. The computer was programmed to present a variety of saturated and unsaturated reds and blue-greens; each colour being preceded and accompanied by either (a) a low tone in the left ear, or (b) a high tone in the right ear.

The task that Q had to learn was to respond to saturated colour trials according to the laterality of the tone (ignoring the hue); and to unsaturated colour trials according to the hue (ignoring the sound). The rationale of the technique was that, in fact, Q cannot be expected to succeed unless he pays attention to both stimuli on each trial; yet his success is measured in terms of his response to only one of them. If the contingencies are so arranged that on most trials he presses the left key to a low tone paired with red and the right key to a high tone paired with green, then insofar as he succeeds in mastering the (initially bewildering) task, he also incidentally acquires a pair of singular response-readinesses each of which are directed to both classes of stimuli, in such a way that the low tones become organized into the functional equivalence class of 'red', and the high tones into the functional equivalence class of 'green'.

The concept of ultrastability is here seen to be more apposite than in the Howells paradigm. In our case, there is initially a state of almost complete disequilibrium insofar as the limited environment (defined by the programme entered into the computer) is concerned. Given certain (initially unrecognized) regularities in this environment and given a subject with the ability and motivation to come to terms with them, it is predicted that a new equilibrium will be acquired which does not depend on failure to adapt, as in the Howells situation, but the opposite.

At this point the reader may be wondering in what essential way this differs from the second of Howells' three "basic conditions", "that the sensory functions involved must normally work together co-operatively in achieving a psychological end or goal, so that this end becomes the chief object of attention rather than the sensations themselves". The answer briefly is that there is no difference--if

one goes no farther than this. But I have argued that even supposing Howells himself fulfilled this condition (and there are grounds for uneasiness in regarding the avoidance of dismissal on the part of his subjects as a "psychological end or goal to be "achieved") it was of such a nature as to defy replicability. A fuller discussion of this point may be more pertinent later on.

Having given a bare outline of the basic features of my own experimental paradigm, it is time to specify them in some detail.

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3.8 Designing the Computer-Controlled Puzzle Environment

We recall that the solution to the experimental puzzle is to respond to the sound if the colour is saturated, and to the hue if the colour is unsaturated.

Before describing the details of this arrangement, there is an additional requirement that both Howells' and the Cape Town results called for: an elaboration and refinement of what he called the "test trials".

It should be remembered that Howells' stated motive in introducing these tests or reversed trials was to "obtain objective evidence" of the experimental development of synaesthesia. We are not sure whether the "conflict" thus introduced was also initially designed to maintain Q's attention, but this is not material. It certainly served this purpose and produced the vicious circle (vicious, that is, from Q's point of view) of greater attention → stronger association of tone with colour → more errors → still greater attention, and so on. Our admiration of the ingenuity of this arrangement should not, however, lead us to overlook the importance of incorporating, within the structure of the conditioning procedure, some means whereby we can obtain a running assessment of the development in Q of the new constancy we are attempting to establish.

Before describing the elaboration of Howells' test trials which I finally introduced, it is necessary to describe the simple but in some ways unorthodox colour-mixer in use which permitted a "hook-up", via a digitizer and suitable relays, to the output register of the computer. Instead of a mechanical arrangement whereby more light was allowed to pass through one filter as the other was occluded, an electronic dimming technique was employed. As in Howells' "chromatoscope" (a term not found in any other reference consulted), there were two lamps, each provided with a red and a blue-green filter (for full details see Appendix 1, p.246), the voltage across each of which was reciprocally adjustable in such a way that as the luminance of one increased that of the other decreased. This was accomplished through the use of two tri-ac dimmer circuits which were each controllable by a small (half-watt) 500K potentiometer. By using a dual (coupled) potentiometer and wiring the two dimmer circuits so that rotation of the shaft lowered the voltage across one lamp as it raised that across the other, a fair approximation to a linear mix was obtained.

Purists will of course maintain that since the colour-temperature of each lamp was continuously changing, and that since at the neutral point the chromaticity co-ordinates of the lamps at their reduced voltages were a good deal closer to yellow than under normal operation, it must have been impossible to obtain a true neutral (achromatic) point. This is conceded, but the solution to the yellowness of the neutral point was simply to use "bluer" filters than would otherwise have been necessary. The fact that the transition from saturated red through the achromatic region to saturated blue-green could not be conveniently described by a straight line joining the relevant co-ordinates on the C.I.E. Diagram² was far outweighed by the fact that E could specify, within fairly close tolerances, a whole range of colours varying in chromaticity for presentation to Q.

This immediately suggested that instead of having one unsaturated colour (of each hue), the arrangement be replaced by presenting Q with a number of evenly graduated colours between the normal unsaturated red and unsaturated blue-green.

It will be convenient at this stage to introduce some abbreviations:-

Let R = saturated red
 G = saturated blue-green
 $r(i)$ = unsaturated reds
 $g(j)$ = unsaturated blue-greens
 L = low tone (260 Hz) in left ear
 H = high tone (390 Hz) in right ear

A digitizer was constructed which permitted any one of R , G , $g(0)$, $g(1)$, $g(2)$, ..., $r(13)$, $r(14)$, $r(15)$ to be presented at any one time. That is to say, in addition to the saturated colours, there were 16 unsaturated colours, and of course these latter passed through an achromatic region which varied in position and extent from subject to subject. The most saturated of these, $g(0)$ and $r(15)$, were chosen in such a way that they were unequivocally supraliminal as to hue. The steps 0-15 were defined with reference to an arbitrary vernier scale which was fitted to the dual potentiometer referred to above. The vernier dial was marked 0-100, and on this scale, $g(0)$ to $r(15)$ corresponded approximately to settings 71, 68, 65, ..., 32, 29, 26*. Setting 0 was a red about midway between a fully saturated R and neutral; 100 was a green about midway between a fully saturated BG and neutral.

These details are mentioned in order to explain the motivation behind the design to be described below. One of the most vexing of the problems encountered in the Howells replications was the extreme variability of subjects' own settings of the colour-mixer to obtain a subjective neutral grey, using the method of adjustment described by Howells. The "interserial adaptation effects" (Hurvich, Jameson and Cohen, 1968) were not brought under control until the later programme involving conditioning of gaze-contingent hue responses was well under way and a computer-controlled means was devised of interrupting the visual stimulus so that Q was able to view the test patch for a specified time only, with specified re-adaptation intervals (four seconds was found to be the most convenient for each). For the present tone-contingent study, however, the decision was taken to conduct pre- and post-tests using a method of single stimuli in which Q was required to make absolute (dichotomous) judgements of 'red' or 'green'. The stimuli comprised the range of 16 unsaturated colours, $g(0)$ to $r(15)$, and were presented in random order via a specially prepared computer programme in which each of these colours was paired both with L and with H , the number of presentations of each colour and tone combination usually being 8 or 10.

*For luminance readings, see p.246a.

Since these same colours were to be presented as part of the conditioning programme, it seemed highly desirable that a given number of each should be paired with both L and H and that these should constitute what I shall call assessment trials. So that, instead of having to rely on errors made with only one r and one g, it would be possible to keep track of the development of Q's tone-contingent hue response-readiness by monitoring the distribution of his "neutral" points (to be defined later) under the respective influences of L and H. It was not deemed advisable to use an equal number of all 16 colours for both reversed and unreversed trials, since this might weaken the conditioning effect, which is obtained by presenting a preponderance of non-reversed trials, LA, Lr(i), HG, Hg(j), over reversed trials, HR, Hr(i), LG, Lg(j). It will be recalled that the ratio used by Howells was 20 to 1, but the present design required Q to be oriented towards problem-solving rather than towards sheer staying-power.

Preliminary pilot runs indicated that an overall ratio of no more than 3 to 1 in this connection was enough to induce even a sophisticated subject who was aware of the contingencies of the experiment (the writer, for example) to make errors. The decision was taken thereupon to limit the "assessment trials" to the range g(4), g(5), ..., r(10), r(11). This constituted the central 8 of the total of 16 unsaturated colours, and in a full session of 512 trials, they were each presented 8 times as non-reversed trials, and 8 times as reversed trials. (Whether a given digitized setting was paired with L or with G depended, of course, on Q's subjective mid-point, which was determined during the pre-test). It should be understood that the reversed trials in which the colours presented lay outside the digitized range, 4-11, were not considered as test trials. Their function was to introduce conflict and maintain alertness rather than to act as indicators of perceptual changes. There was a twofold weakness inherent in Howells' "test trials": (a) there was only one r and one g involved, and (b) there were 19 times as many "practice trials" as "test trials". Howells error-curves would thus have been difficult to interpret even if he had counted errors on non-reversed trials.

We are now in a position to set out the final overall distribution of conditioning and reversed trials which were employed throughout. To simplify matters, I shall assume that the subject's midpoint is halfway between digitized settings 7 and 8.

Conditioning (non-reversed) Trials

<u>Tone</u>	<u>Colour</u>	<u>No. of presentations in complete 512-trial session.</u>
L	R	104
H	G	104
H	g(0) to g(3)	14 each
H	g(4) to g(7)	8 each
L	r(8) to r(11)	8 each
L	r(12) to r(15)	14 each
		384 trials

Reversed Trials

<u>Tone</u>	<u>Colour</u>	<u>No. of presentations in complete 512-trial session</u>
H	R	24
L	G	24
L	g(0) to g(3)	2 each
L	g(4) to g(7)	8 each
H	r(8) to r(11)	8 each
H	r(12) to r(15)	2 each
		128 trials

Grand Total 512 trials (= 1 complete session)

It will be noted that whereas the overall ratio of non-reversed trials to reversed trials is 3 to 1, the corresponding ratio for saturated trials only is $4\frac{1}{3}$ to 1, and for unsaturated non-assessment trials only it is 7 to 1.

It is now necessary to give some indication of the very flexible range of options available to E for controlling and maintaining Q's "puzzle environment".

The first set of options, namely a specification of how many trials there were to be in a complete session, and the distribution (and random sequence) of non-reversed and reversed trials for all the available colours, was one which was exercised in the manner indicated above, and was performed by punching paper tapes which had to be loaded

into the computer's memory in conjunction with the main programme. Two separate randomizations were prepared to minimize Q's memorization of critical trial-sequences.

Once the basic and auxiliary tapes were loaded, the computer began asking, via the teletypewriter, for values to be specified by E of the following parameters (prior to a given session):-

- (a) Tone duration (preceding colour) in milliseconds
- (b) Tone-plus-colour duration, in milliseconds
- (c) Feedback duration, in milliseconds
- (d) Interval between trials, in milliseconds
- (e) The feedback pattern. Four separate parameters were specifiable in this connection. Negative and positive feedback were separately specifiable for both reversed and non-reversed trials. Moreover, the feedback ratio in each category could be specified, subject to the limitation that the ratios available were 1 in 1 (100% feedback), 1 in 2 (50%), 1 in 3, 1 in 4, etc. down to 1 in 513 (zero feedback). There was thus no ratio available between 100% and 50%, between 50% and 33%, between 33% and 25%, and so on. This proved to be a very minor inconvenience.
- (f) The "midpoint" and the "neutral range". This requires some comment. There is, of course, a significant variation among "colour-normals", with respect both to location and scatter of the "neutral point" in the chromaticness (hue-plus-saturation) continuum between two complementary colours. This diversity required that each subject's pre-test results be scrutinized in order to assess (i) his approximate mid-point, and (ii) his approximate range of confusion (or interval of uncertainty). Specification of the "mid-point" (which had to be indicated as lying between two adjacent digitized settings, say 7/8 or 8/9) automatically decreed the division of the tone-and-colour pairings in both the reversed and non-reversed trials. Specification of the "neutral range" decreed that on these digitized settings no feedback of

the kind mentioned above would be provided, no matter what these prior specifications were. The "neutral range" could extend from zero, (i.e. no settings excluded from feedback) to the entire unsaturated 0-15 range, which latter was tantamount to specifying zero feedback on all unsaturated trials, and could thus be treated as an adjunct to (e) irrespective of Q's real neutral range, as determined in the pre-test.

- (g) The number of divisions or blocks into which a full 512-trial session was to be divided for purposes of giving Q provisional feedback regarding his performance. This allowed E the option of dividing a full session into 2×256 , or 4×128 , or 8×64 trials, etc. At the end of each "feedback block", the computer halted the presentation of stimuli and the teletypewriter printed Q's percentage (overall) correct responses for that block, which E relayed to him via the intercom. The next block would start only when E (and Q) were ready. The usual division employed for the 9 subjects was 8×64 trials.

In writing a programme of this kind, the programmer often encounters logical cul-de-sacs which E has elided or overlooked in his specifications. One example in this connection was: how should delayed responses or non-responses be dealt with? There are several possibilities. Howells apparently made no effort to control this variable. Since in the present design, the concept of "response-readiness" was central, both accuracy and speed of responding were considered to be jointly important as criteria of performance. The decision was taken, therefore, to count a response made "too late" or "too early" as an error³, and to regard the relevant presentation as a "ruined trial". A key-pressing response that was made before the onset or after the termination of the colour stimulus fell into this category.

There were three feedback signals. A motorcycle hooter ("squawker") indicated a wrong key-press. A buzzer indicated "too late or too early response". A door chimes ("ding dong") served as a positive feedback, i.e. correct key-press, performed within the time allotted.

At the end of the 512-trial session (i.e. after the last "feedback block") the teletypewriter presented E with a very full breakdown of Q's performance, including:-

- (a) number and kind of errors for each category of stimulus presentation, i.e. as listed on p.84.
- (b) mean reaction time (and SD) in milliseconds for each of these categories
- (c) overall mean reaction time (and SD) for the whole session, and
- (d) total number of "counted trials", i.e. presented trials minus "ruined trials".

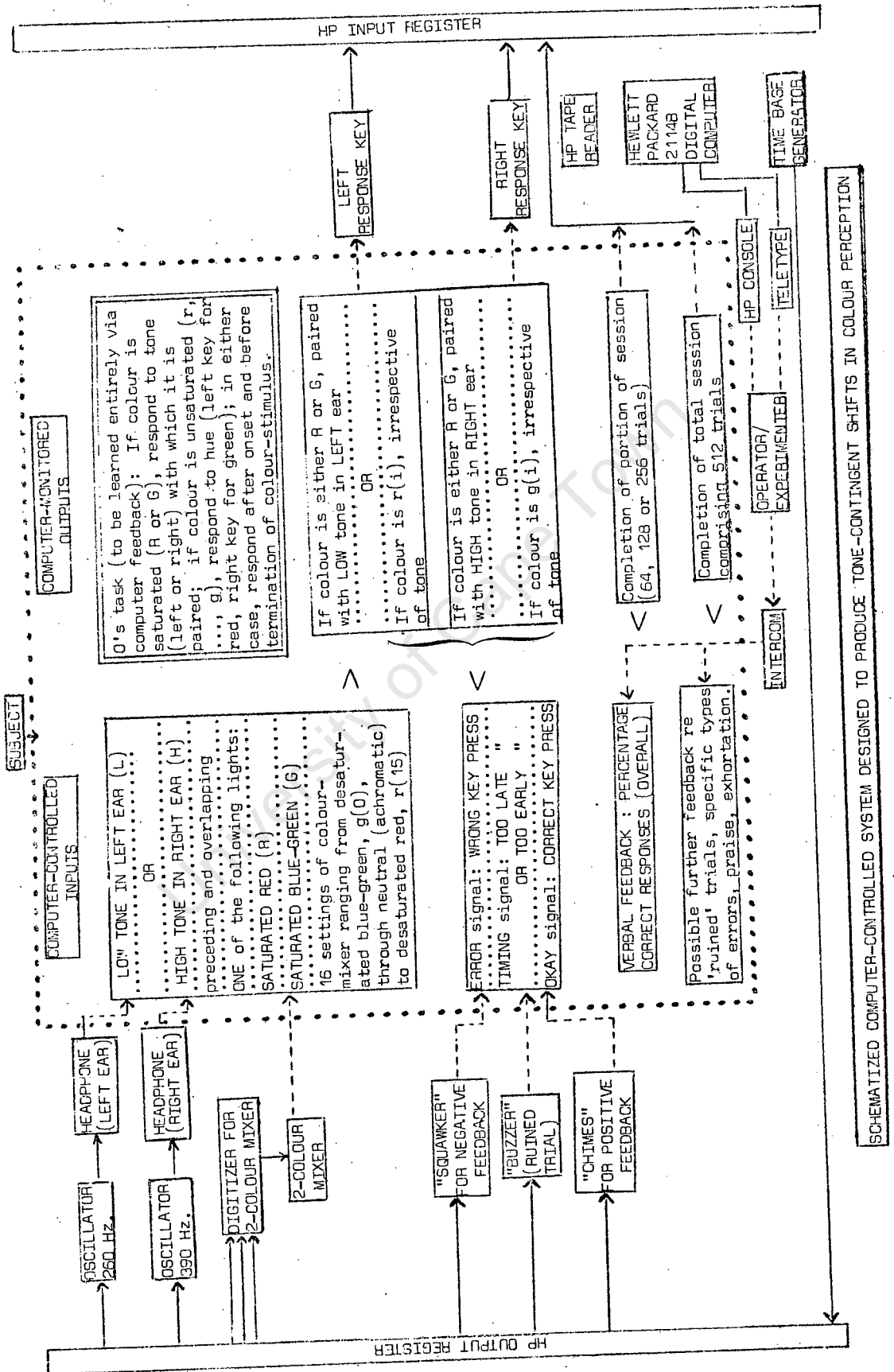
E could exercise his discretion as to the nature of Q's post-trial feedback. For example, he might stress the fact that Q was taking too long over his responses, or that he was making too many key-pressing errors on "reversed" saturated green trials; but he could choose to suppress the nature of the distribution of errors on unsaturated trials. (The strategies actually employed will be discussed below). An example of a typical TTY printout is provided in Appendix 4.

Fig. 2 is a schematized block diagram giving an overall picture of the computer-controlled environment designed to produce the Howells-effect. The relevant Fortran programme listings have been reproduced in Appendix 2.

Notes

2. The chromaticity co-ordinates of the saturated colours obtained from this colour mixer and the approximate locus of the transition through the achromatic region are provided in Appendix 1, p.246.
3. A response made "too late" or "too early" contributed to the total tally of errors made by Q. When providing intra-session feedback, E could use his discretion as to whether or not to disclose the ratio of these "ruined trial" errors to actual "wrong key press" errors.

Figure 2



3.9 The General Strategy Outlined

Having constructed this very versatile experimental system, there remained the question of how best to exploit its potentialities.

The decision to recast the whole design was taken in order to invoke, and centre upon, the notion of ultrastability. Since this strategem derived directly from Taylor's research philosophy, it is necessary to outline its essentials.

Although Taylor is typically concerned with the upset in equilibrium that occurs when Q first puts on a pair of reversing spectacles (say), his policies are general enough to be applied quite directly to the puzzle environment previously described. Taylor's method of resolving the nomothetic/idiographic problem in psychological research can best be illustrated by the following quotations.

The assumption that the system is multistable [i.e. one containing many subsystems, each of which is ultrastable] enables us to calculate the changes in behavior that are induced by prolonged wearing of the device. In making this calculation we must be guided by our knowledge of the specific system of drives operating in each particular subject. Behavioral errors that are of primary importance in one subject may be of negligible significance in another, so that the details of behavioral adaptation are likely to vary from one subject to another.

...For an experiment is performed not on a piece of raw material that may be expected to have essentially the same properties as any other sample of the same raw material...

We cannot assume that the process of adaptation to [a primary operation] will be entirely independent of the state of adaptation of the system as a whole, or that the only information we need to enable us to calculate the results is an exact statement of the transformation applied to the afferent function. That statement is necessary but not sufficient. In particular, we must take account of the fact that the mature subject can understand and use language...

This is even more important when we try to calculate the perceptual results of prolonged disruption of an afferent function. For the most obvious way we have of testing our deductions is by asking the subject to describe what he perceives...

In short, the system on which we propose to experiment is vastly more complex than that which we have assumed to be active in infancy, so that while the results are in general calculable, we are likely to find some irregularity, because of course we shall not always know beforehand what hitherto unsuspected sources of perturbation are active in any specific subject. Consequently, if irregularities are found, that does not necessarily prove that the theory is false, since it may only mean that an essential variable has been neglected. On the other hand, if certain distinguishing characteristics of the subject are known, and we can deduce that these will affect the course of behavioral adaptation in a distinctive manner, the theory can be subjected to a searching test. For in that case we can calculate that the perceptual field must have distinctive properties corresponding to the behavioral peculiarities. If such deductions are not confirmed, the theory is condemned.

(Taylor, 1962, p.163-166)

(Emphasis added)

A critic might argue that, given such flexibility of interpretation, the experimenter cannot lose. This issue will be debated in a more appropriate place. For the present, I should like to indicate how I tried to apply Taylor's approach to the present problem.

Since I proposed to place a highly adaptable organism in an environment whose characteristics I could alter within moderately wide limits, there were two sets of parameters whose values were largely unknown to me before the start of the experiment. It is true

that in the case of the subject himself I could attach values (sometimes only approximately) to such particulars as, "degree of acquaintance with psychology", "degree of awareness of aim and outcome of the experiment", "ability to discriminate fine differences in chromaticity", "motivation to succeed in a problem-solving situation", "motivation to work conscientiously over protracted periods", and so on. And I could, if I wished, employ any of a whole array of "personality tests" purporting to isolate and measure these and other traits.

Similarly, with the very large number of experimental variables under my direct control, I could employ what Taylor (1962, p.306) has called "the impressive panoply of instruments collectively known as 'Experimental Design'" to establish "statistically significant" covariations between the independent and the dependent variables.

Taylor's premises, coupled with my own predilections, induced me to proceed quite differently. Perhaps it will be useful if I begin by describing my own experiences as a subject in the puzzle environment. Far from being able to cope smoothly and calmly with a task whose contingencies I was myself the architect, I was immediately thrown into a state of confusion, and even immobilization, by the insidious sequence of tones, colours, "buzzes", "squawks" and (occasionally) chimes. One subject was afterwards able to say that he could organize them into a kind of orchestral harmony and, as he put it, "ride along with them", but my own reaction, even after a thousand trials, was one of amused chagrin at not being equal to the insistent demands and rebukes coming from the machine next door.

The experience was a valuable one. It reminded me that, since Stratton, it has been evident that there are very wide individual differences in the ability to tolerate temporary destruction of the stable functioning of a behavioural (and perceptual) subsystem. Although in this case it was not an existing subsystem whose stability was being disrupted, the ability to discover the latent regularities of the initially chaotic artificial environment and then improve one's skill in meeting its impositions was one that not every subject would possess to the requisite degree. This meant, firstly, that I would have to interview prospective subjects in order to gauge the likelihood of their success at regaining and maintaining ultrastability

and, secondly, that having put a batch of screened subjects through their paces I would have to reject any who nevertheless proved unable to meet my criteria.

It may be objected that such a procedure vitiates the generality of Taylor's theory. Taylor's rejoinder (if I interpret him correctly) would be twofold: (a) that the issue is a purely practical one because, although the theory is completely general, one has to take individual parameters into account, and in some cases motivational parameters are such that the limited repertoire of incentives available to the experimenter is simply insufficient to produce the necessary amount of drive, and (b) to the extent that some subjects' reports are haphazard or careless or deliberately misleading, we have no option but to exclude them.

A good scientist tests his apparatus...by subjecting it to a series of standard operations. If the results deviate significantly from what is expected, the apparatus is overhauled or replaced. Similarly a psychologist does not employ subjects whose capacity for reporting is defective, for whatever reasons. A good psychologist will test the reliability of his experimental subjects by exposing them to certain standard situations. For example, he will not use color-blind subjects for experiments on color vision. If any report [in a colour-vision test, presumably] deviates markedly from the norm, the subject is rejected, and it is of no consequence whether the deviation be due to inadequate vocabulary, a defect of character, a bias against the experimenter, unwillingness to submit to the discipline of the experiment, or anything else.

(Taylor, 1962, p.353-354)

That this is not an entirely satisfactory way of dealing with such problems is evident when one considers the report of Vogelmann's subject M (see p.64f.) who seemed to be genuinely unsure as to whether or not she actually saw the colours that she reported!

We shall have reason to return to this kind of dilemma. It is time now to deal with the selection and characteristics of the subjects I used in my attempt to reproduce the Howells-effect.

3.10 Subjects

Of the nine subjects who took part in the conditioning of tone-contingent hue-responses, two were fully aware of my aims, and one of these knew exactly how I intended to elicit the desired reactions. They were Nevil Doxey and Silke Vogelmann, respectively. Nevil and I had been co-operating in a research project on the induction of "hallucinatory" hue responses by hypnosis, suggestion and direct instruction (Doxey and Abramovitz, 1972). Silke, of course, was responsible for the first breakthrough in producing the Howells-effect or something very like it, and had been involved in the Cape Town experiments from their inception. I had told her of my design and invited her to act as a subject in the preliminary trials. She agreed and it was understood that she would actively resist the conditioning process. Nevil, on the other hand, knew what effect I was trying to produce, but I had concealed from him how I hoped to achieve it. I had mentioned that the method was such that conditioning would seem to be inevitable, and he responded to the implicit challenge. Another psychology graduate, Stan, having heard about my proposed experiment, volunteered to act as a subject. Although at the time I thought he knew what my aims were, it transpired, during the de-briefing, that in fact he did not.

These three subjects had this in common, that they were sophisticated psychology graduates and that they were not paid for their services.

The other six were all paid, but of them one was my research assistant, Stephen, and he therefore belongs to a special category. Although I had tried to conceal the aim of the experiment from him, it proved virtually impossible in the circumstances. He had completed an undergraduate course in psychology. Of the other five paid subjects two, Joan and Emily, were highschool pupils; while Steve, Eric and Mike were university students—but of these only Mike had taken a course in psychology.

The paid subjects were all recruited by Stephen, as part of his job. They were told that they were needed for a full 12-hour day, 8 a.m. to 8 p.m., for which they would receive the sum of R10.00, plus meals and refreshments. The three unpaid subjects were asked to make themselves available for the same period, and were also given meals and refreshments.

All subjects were tested on the 11th Revised Edition of the Ishihara Tests for Colour-Blindness (Ishihara, 1954) as well as on the Farnsworth-Munsell 100-Hue Test of colour discrimination (Farnsworth, 1957). None were found to be deviant in any noteworthy respect. They were not, however, tested for hearing acuity nor for pitch discrimination. This was to prove a blunder in the case of at least one subject.

3.11 Procedure

The 9 subjects were each tested during a 12-hour day over a two-week period, as follows:-

February	3	Stephen
	7	Stan
	9	Steve
	10	Nevil
	11	Silke
	14	Joan
	15	Emily
	17	Eric
	18	Mike

On the morning of the experimental day each subject was told:

In the following series of experiments you will sometimes be told what to do, but sometimes it will be left to you to find out for yourself. The apparatus is under the control of a computer which may be differently programmed at different times. It can be programmed to signal to you when you have made a correct response and also when you have made an incorrect response. On some occasions you will get such signals every time you make a response; on other occasions only intermittently or not at all. In all cases, however, this information is immediately available to me the experimenter, and to my assistant,

who will be operating the computer.

When you have established the nature of your task it is understood that you are to work as accurately and as quickly as you can. The computer will in all cases measure your reaction time to the nearest one-thousandth of a second, and I will receive a statistical analysis of accuracy and speed after each brief session. On some occasions I may tell you how well you are doing, on other occasions not. You may ask me questions, but I will not necessarily answer all of them. (If you are interested, you will receive an explanation after all subjects have completed the whole series of experiments.)

During most of the day you will be working in the Reaction-Time room under conditions of almost complete darkness. There will, however, be frequent rest and refreshment periods during which you may relax in any way you please (within limits).

It is important to record that of these subjects, the first four were given special goggles to wear when they were not in the darkroom. In the case of Stephen, Stan and Steve the goggles were fitted with hue-attenuating filters which mimicked as closely as possible the Kodak Wratten No.90 "monochrome viewing filter". According to the manufacturers, this filter allows one to distinguish between red and green, but the difference between colours is "dulled" (Eastman Kodak, 1970, p.47)

Nevil was subjected to an even greater photic deprivation. The filter combination in his case allowed the transmission of only a very faint reddish light. He was only just able to make his way on his own outside in bright sunshine. Indoors, under good fluorescent lighting, he had to rely mainly on touch. The transmission characteristics of the filters used in these goggles will be found in Appendix 3.

The motive for having subjects undergo this kind of between-session deprivation was (a) to inhibit any fortuitous counterconditioning outside the laboratory situation, and (b) to loosen the chromatic anchoring effect which objects of known colour tend to confer.

The subject was then led to what was called the "Reaction-Time Room" (to minimise the possibility—in the case of "unaware" subjects—of their surmising the general experimental objective). He was seated

at a table with two response keys, right and left, bearing the letters R and G respectively. (In addition there were two stands to right and left bearing the letters R and G in silhouette and placed in such a way that Q would be able to see them in the darkened room during the exposure of the test field.) He was then addressed as follows:-

On this occasion your task is to react to the colours which will appear here [pointing to the aperture of the colour-mixer]. As soon as a light appears in the square decide whether it is reddish or greenish. If it is on the red side, say "red" and press the left key; if on the green side, say "green" and press the right key; if you're not sure, guess. Be quite sure that you know which key goes with which colour. These silhouettes may help you, should you be unsure at the time of making your responses. Work as accurately as you can. Do not be over-hasty in making your responses, but neither should you delay too long in coming to a decision with "difficult" colours. You will wear these headphones [E tests that Q hears the low tone in his left ear and the high tone in his right ear], but respond only to the colours.

Any questions?... I shall be leaving you now but you can communicate with me through this intercom. Do not remove your goggles until I tell you to do so.

All testing-sessions, including briefing and de-briefing, were tape-recorded. An example of the printout obtained from the computer's teletypewriter at the end of the test is shown in Appendix 4. Note that in this pre- and post-test, E could specify the following parameters:

- (a) Tone duration (preceding colour), in milliseconds,
- (b) Tone-plus-colour duration, in milliseconds, and
- (c) Duration of pause after Q has made his key-pressing response.

The number of presentations of each of the 16 digitized settings, $g(0)$ to $r(15)$, was usually 8 for each tone-pairing, that is Q had to make 256 responses in such a test. Given parameters of (a) 0.5 secs. (b) 1.0 seconds, (c) 0.5 seconds, and a mean reaction-time of 0.65 seconds, it meant that a testing session lasted about 11 or 12 mins. (For those subjects wearing goggles, no special period of dark-adaptation was provided).

If the results of the pre-test were satisfactory, that is if one could obtain a reasonably clear indication of the subject's mid-point and "neutral range", the main conditioning sessions could start. If, however, the pre-test printout showed an abnormally large scatter, or a bimodal distribution, the test was repeated, Q being asked to take more care with his responses.

(It was understood that the pre-test would not necessarily be commensurable with the post-test, in that the large practice-effect, as a result of the day's trials, could materially jeopardise any attempt at direct comparison. What was hoped for, however, was to demonstrate a significant pre- and post- difference between the tone-contingent differences. This point will become clearer when the results are presented and analysed.)

Armed with Q's mid-point and, if any, his "neutral range" (some subjects' scatter was so small, that the values of the digitized settings were too coarse to reveal a decent distribution of their confusion range), E was in a position to specify all parameters to start the experiment proper.

After a rest-interval, Q was again led to the experimental room and addressed as follows:-

This part of the experiment involves both sounds and colours, but I do not intend to tell you what your task is. [The R and G signs had previously been removed]. You will receive one of these signals [buzzer and squawker illustrated] when you make an error, and this signal [chimes] when you make a correct response. On some occasions you may receive no signal at all. I want you to aim at maximum accuracy and speed of response. Any questions? [No replies were given concerning the nature of the task itself, but if Q asked about the keys, he was told that they were the only medium of responding available to him].

Having loaded the necessary punched tapes, the operator was given E's parameter specifications on a special form prior to each session. For the first session of the day, the time parameters were made fairly large, the feedback was set at 100%, positive and negative, on all trials, and the number of "feedback blocks" was set at eight.

To the extent that the subject "solved" the puzzle and then began to work more quickly and accurately, the various time parameters were "tightened", and intermittent feedback schedules of various patterns were introduced. There was no "systematic" variation of parameters from session to session or from subject to subject. (All post-session debriefing interviews were tape-recorded.)

The general strategy was to allow Q a reasonable time to recover from his initial confusion (what Howells called "the debacle of errors"). If he failed to "crack the code" within about two full sessions, he was given increasingly more direct hints as to how to succeed. The emphasis was placed on continual improvement of his scores from one feedback-block of 64 trials to the next, without however revealing to him the distribution of his errors. This was a tactic which paid off handsomely, even with "aware" subjects. As will be seen when their results are discussed, they had little or no idea that their responses to the unsaturated colours were being influenced to any significant extent by the tones.

As a given subject achieved greater proficiency, he was told that the task was going to be made more difficult (usually in an undisclosed way) from session to session. It was here that I first realised how inadequate was the puzzle environment I had devised. Apart from the fact that most subjects took up the challenge of improving their speed and accuracy scores, many of them nonetheless showed disappointment that there weren't new puzzles to solve. "Will the basic task be the same for the rest of the day?" was their refrain. Some of them weren't sure that I wasn't in fact duping them, and looked for hidden puzzles. For example, Stan, my second subject, tried to work out the pattern of reinforcements by describing the most intricate colour-and-tone sequences, and I was obliged to inform him directly that there were no more puzzles, since his hypotheses were interfering with his performance. I shall devote more discussion to this point later. I should like it to be remembered, however, that these were intended to be preliminary or pilot runs designed to get an idea of the subjects most likely to be susceptible to the general approach adopted and also of the complex of parameters that would best serve to elicit the Howells-effect.

3.12 Results: Overview of Qualitative Data

It is important to recall that, for Taylor, the final and most convincing test of whether or not a given perceptual phenomenon has occurred is simply to ask the subject to describe what he perceives. By this token, a fully successful outcome of an experiment such as this would be one in which the following is observed. The subject (without any tonal stimulation) adjusts the colour-mixer to obtain his subjective neutral point, which he calls "grey" or "white" or "colourless". The colour-mixer is switched off and then this same setting is presented, over several trials, but on half the occasions it is accompanied by the 260 Hz tone in his left ear, and on the other half by the 390 Hz tone in his right ear; these tonal accompaniments being randomly distributed. If he consistently says that the colour is red(dish) when the low tone is sounding in his left ear; and green(ish) when the high tone is sounding in his right ear; and if we have no grounds for calling his self-reports into question; then we can say, with complete confidence, that a perceptual transformation has taken place.

Since none of my nine subjects, when tested in the above manner, provided the required reports with anything approaching this degree of consistency, must it be said that the experiment was a failure?

An unsympathetic critic would say, "Yes, by your own criteria you have failed to produce the Howells-effect; if that was your primary aim, it has simply not been realised".

A sympathetic critic might say, "Your criteria are surely over-stringent. Your 9 subjects underwent a massed-practice training schedule which ranged from $3\frac{1}{2}$ to 6 hours during the course of a single day. Bearing in mind the number of hours of training that Howells' subjects underwent, and the results of several extended experiments reported by your own students, your expectations were too high".

My own reaction to this question would be:- by the criteria I have mentioned the experiment was neither a failure nor a success: it was a disappointment. But--and I would like to emphasize this as strongly as I am able--it was the only aspect of the experiment that was a disappointment. In practically every other respect it provided me with an insight into the value of Taylor's axioms regarding perception which I hope I can adequately convey to the reader.

In admitting that this aspect of the experiment was a disappointment, what I am really saying, of course, is that in spite of my stated aims that I was engaged in a screening procedure for selecting subjects to be trained over a longer period, I had in fact hoped to demonstrate, at least minimally, that a perceptible tone-contingent divergence would be manifest. In fact, when we come to analyse the quantitative data for the testing sessions, it will be seen that no less than 7 out of the 9 subjects showed a statistically significant tone-contingent divergence in hue responses with P values extending from 0.05 to 0.000006 (but which, expressed in the psychophysical yardstick that I have still to define, ranged between only one half to two "J-units"). Moreover, of the two subjects who did not show this shift, neither showed discrepant performances (in the sense that one might have predicted otherwise on the basis of Taylor's theory).

But my chief objective in this section is to argue that, important as the quantitative results undoubtedly are, I regard the qualitative data, namely the subjects' self-reports during the experimental and testing sessions, as having the most profound significance for our understanding of the nature of "colour-sensations" and indeed of sense-data in general.

In order to try to substantiate what must seem a rather exaggerated claim, I shall first of all give a general overview of certain common elements in certain of these reports and then present details for each subject.

It should be borne in mind that these data come from many hours of tape-recordings, which if transcribed in full would fill a volume on its own. The reader will have to take it on trust that I am not selecting those elements which suit my thesis and suppressing those that do not.

The most important and the most frequent thread which ran through at least the first five subjects' reports, especially in connection with the experimental sessions, but also in the testing sessions was this: that some of their responses (and some of the non-chromatic stimuli that accompanied and followed them) were reported as being temporally prior to their perception of the colours themselves. To put it in another way, instead of attributing correct or incorrect responses to veridical or non-veridical perceptions, they tended to ascribe the quality of their perceptions to the accuracy or otherwise of their key-pressing and/or verbal responses. And they related response-accuracy to such contingencies as laterality of tone and the nature and presence of feedback signals (which, of course, came after their response).

I will anticipate, by saying that these reports put me in mind of William James' dictum: "We do not run away because we are afraid: we are afraid because we run away". I would unhesitatingly say that under the conditions of the computer-controlled environment described, it could truthfully be said of at least half the subjects that there were times when they did not make errors merely because they misperceived the stimuli; they misperceived the stimuli because they made errors!

Of course, I do not doubt that in many cases their response-accuracy was a function of their perception. This may seem to be an anomalous position to take, but I hope to be able to justify it.

That it seemed logically absurd to imply that their perception was a function of their response-accuracy, rather than the other way around, was also a characteristic of their own reports. They expressed puzzlement, if not in so many words, then in their tone of voice and the manner in which they formulated their explanations.

Again, to anticipate, we must try to project ourselves into the highly artificial environment in which they were placed, the puzzle they were obliged to solve ("respond to the tone if the colour is saturated; to the hue if it is unsaturated"), and the promptness of reaction they were required to maintain over protracted periods. To the extent that we can successfully do so, we may get a glimmering of how such an environment differs from the conditions of everyday experience.

Probably the most important factor here is time. The temporal contingencies imposed by the computer were "un-natural", by which I mean that if one were to seek parallels outside the laboratory, then a good enough example would be the working conditions in an assembly line of a modern factory, where the operations of the human attendant are dictated by the inexorable demands of the "machine" (including, of course, its "programmers").

Subjects made frequent reference to the time available to make their responses. Recall that, within a given session of 512 trials the time-parameters specified could not be altered. Yet they frequently said that when they made errors, the time on hand was too brief; whereas when they made correct responses they had "all the time in the world". I would venture to predict that assembly-line workers must often experience the kinds of time-distortions reported by my subjects, and would, of necessity, develop new modes of perception, as a result.

Another phenomenon frequently reported was one which might be dubbed the "error-chain", and its consequences. Subjects reported that if things were going "smoothly", that is if they were responding correctly and rhythmically, they "saw" the colours well and in good time. If, however, they made an unexpected and perhaps inexplicable error, then a whole chain of errors followed, resulting in a chromatic as well as temporal instability; which prevailed until they were able to get "into the rhythm" again with their responses.

3.12 Qualitative Data

Virtually every subject reported colour-distortions of one kind or another as having occurred during the experimental and testing sessions. These were quite varied and often dramatic in nature and extent. It is impossible to make adequate generalizations about them. The tape-recordings were mainly confined to the debriefings after the testing and experimental sessions, and it was difficult to correlate Q's actual performances with his self-reports. I shall content myself with specific quotations from these reports.

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3.13 Qualitative Data: Extracts from Subjects' Self-Reports

Stan. Unaware of real nature of experiment. Unpaid volunteer. Psychology graduate. Highly intelligent. Intensely active, cerebrally. Very curious. Very verbal.

Wore hue-attenuating goggles when outside dark room. Due to computer malfunctions and his own variability on the pre-tests, only 15 sessions were completed during a full 12-hour day.

Solved the puzzle very quickly; couldn't believe there weren't other puzzles of a more intricate nature. Kept trying to work out whether there was a "pattern" in the sequences of stimuli and signals. Admitted that this interfered with his concentration.

After the second experimental session: "I can't discriminate between green and white now, yet I didn't have any trouble at all in the pre-test". (Stan's pre-test and post-test were carried out via his own key-pressing--accompanied by the corresponding verbalization. During training, no verbalizations were required of him.)

"One mistake can set off a train of others. Then my timing goes haywire. I don't seem to discriminate the pale colours so well then. I have to wait until a sequence of dark [saturated] colours appears".

"I seem to have a problem between some greens and some reds. I find that I am discriminating between green and not-green, whereas previously the reds were fairly distinct.

After the post-test (8 p.m.): "I have the same trouble about pale green and pale red colours, but now there seem to be yellow colours as well. I saw no yellow colours during the experimental sessions."

Reported that towards the end of the experiment, "I had a strange 'hallucinogenic' experience. Floating sensations. The light was at the end of a long tunnel. The sounds are playing tunes - like Christmas carols."

Main impression: "Timing is the most important factor. If you lose your rhythm everything goes wrong. Even the colours seem to lose their character. I spent too much time trying to work out what you were trying to do, hence my errors. Very enjoyable experience. Feel quite 'high' now."

On being asked how many different colours had been presented, said, "A white, three shades of pink, three shades of green".

Steve. Paid subject. Unaware of E's aims. Wore hue-attenuating goggles when outside the dark room. Careful, conscientious subject. A little nervous.

After first session: "Very frustrating trying to find out what I had to do, but I've got it now, I think. You normally respond to the sound, unless its a pastel colour. If it's orange sic you press the right-hand key. If it's green you press the left-hand key. It's most difficult to decide between very light green and very light orange."

After the introduction of intermittent reinforcement: "I was confused when I didn't get the bell. I need the bell sound to remind me which is the pale orange and which is the pale green."

"Some tones and colours stay on much longer than others. They're easier to react to. I have all the time in the world. I see them more clearly."

After seventh session: "The greens have become blue, and now I can distinguish them more easily from the orange colours." (E switched off the tones to O's ears and manually operated the colour-mixer. O then reported seeing greens, not blues.)

"The pastel colours come and go. When I had a good run [i.e. few errors] the colours seemed right on time; afterwards they were off time " On being questioned, "When they're off time they come and go. I'm not sure what happens, really".

"Sometimes, when you told me I made many errors, I thought I was right most of the time. Can't work out why."

"The middle colours all look white now--only the extremes look red and green. Have you changed the colours?"

"The pastel colours just merge into one. I'm working more by sounds than by colours. But then the colours seemed to come back as I made less errors."

"Seeing the colours better now. Not reacting to the tones as before."

"On some occasions when I saw what I thought was a pastel green I pressed the right-hand key and got a 'wrong' signal. Then I realised I had really seen a pastel red."

"Whenever I crashed badly [i.e. made a large number of errors] all the colours merged into one another."

"I'm glad whenever I hear the chimes. They're nice. I feel reassured."

After intermittent feedback session: "Couldn't see the reds and blues properly without the chimes. Near the end I literally went by the tones. The colours were coming too fast." On being questioned, "I suppose they weren't really faster than normal—but the pastel colours were more difficult, and there was no help from the machine."

Near end of day (7.20 p.m.) "The lights seemed to be coming towards me. I could discern the colours quite easily. I knew exactly what was going on."

Number of different colours presented: "Two shades of bright red, two shades of pale red, one dark green and one pale green."

At end of day: "Feel fine. Quite relaxed. Was never bored."

Nevil. Unpaid graduate student and research collaborator. Knew aim of experiment but not (initially) what the contingencies were. Prided himself on ability to concentrate. Wore light-occluding goggles.

Asked to describe the task after he had worked it out said, "When I hear the tone in my right ear and I see a pale green or a strong red then I press the right-hand key. When I hear the tone in my left ear and see a pale red or a strong green, then I press the left-hand key."

"I'm suspicious that something else is happening. I think you're trying to do something that I can't work out."

E imposed new task: Name the colour that you see as you press the correct key.

"That made me very flustered. I found it difficult to distinguish the colours. I knew when I had been conditioned [sic]. The squawker usually meant I was uncertain what the colour was."

"When I make less errors I seem to have more time—I work more automatically—I see the colours more distinctly."

"One error produced a train of others. Couldn't figure out what's happening—something is changing. You're giving me new colours. Sometimes they become white—and then I couldn't make any response."

E tested colours manually. Q said, "I think that when you stopped reinforcements it produced a change. Maybe a low tone with red produces white [sic]."

"The pinks are all right but I can only identify the greens by the absence of red. It wasn't like that in the previous session."

After post-test: "I saw the pinks as pink and the greens as green—they were a good green—no whites. Different from [experimental sessions].

Asked how many colours, said: Two greens and two pinks all told. Enjoyed experience. Never bored".

Silke. Unpaid volunteer. Colleague. Knew aims and contingencies of experiment. Agreed that she should actively resist the conditioning process. No goggles. Task learned very quickly and efficiently.

"The unsaturated greens have become reddish. Very difficult to know why I am making mistakes. I am definitely being misled by the tones. It's a peculiar thing."

"The greys which I saw in the pre-test have become a dirty reddish green"

"I can't see the colours properly since you reduced the reinforcements." After 100% reinforcements: "I saw them nicely then."

"If I make less errors I seem to be more certain about the colours and vice versa."

"The unsaturated colours are not clear again. They vacillate [sic] when I make errors especially."

"I no longer have the reddish green phenomenon. I'm not sure often why I make a particular response. I just seem to know."

After post-test:- "It was easy to resist the conditioning process. Feel fine. Tired but well. Never bored."

Joan. Paid subject. High school pupil from U.S.A. No goggles worn. Tape-recording lost. According to notes I made at the time, she was the most "unflappable" of my subjects, and seemed the least affected by the puzzle environment. I discovered halfway through the trials that she had a slight left/right agnosia.

"The colours are okay, I guess, but you don't give me enough time. I need more time to make my decisions."

At end of day, "All the pale colours seem paler than they were this morning, but I can still make them out: a dark red, a dark green, two pale pinks, a pale bluish colour and a white."

Emily. Paid subject. High school pupil. No goggles worn.

"The colours are swimming into one another"

At end of day's trials, before post-test. "The green has become more yellowy than green. The other colours are the same but a bit paler."

After the post-test, she said, "The colours were clearer and more obvious than when I had to press the keys. I'm not sure whether I was seeing them better or whether I had more time to decide."

Revealed during the course of the afternoon that she was "almost totally deaf in the left ear", and that she had gone to bed at 3 a.m. that morning and risen at 7 a.m.

Eric. Paid subject. Non-psychology undergraduate. No goggles. Very alert. Learned task very quickly. Became bored. E tightened parameters and asked Q to name colours as keys were pressed and gave Q -ve feedback when naming didn't tally with key-pressing.

"Pinks are looking white, greens are okay."

"Now greens are looking white, but pinks are becoming pinker."

"Now the whites are becoming pinkish green [sic]."

"When the computer told me I was making late responses, I didn't agree. But I could have been wrong."

Said he was bored, frustrated, very fatigued, exasperated. On verge of tears at times.

Mike. Paid subject. No goggles. Had taken Psychology I. Said after the first session that there were five colours, bright red, bright green, pale pink, pale green and grey. (E gave no quantitative feedback regarding errors, merely told Q when he was doing well or badly, and also stressed late responses.) No de-briefing (after the first occasion) regarding Q's experiences.

3.14 Quantitative Data: Raw and Derived Statistics

An experimenter is obliged (especially in a work of this nature) to present his data in their completely raw state, and also in various stages of digestion. With the advent of the computer this has often resulted in whole volumes being devoted to nothing but un-decomposed printout. Although I have not found it difficult to resist the temptation of adding an extra 2 cm. to the thickness of the thesis, I have also borne in mind the obligation, when presenting culled or semi-processed data, to do so in such a way that the reader who wishes to interpret them from his own axiomatic standpoint will not find the task a frustrating one. I believe there is very little that I have left out--indeed I could be indicted for over-zealousness--but to the extent that I am aware that information has been omitted I shall give my reasons for the apparent negligence.

1. Pre- and post-tests

The reader has already been referred to a specimen printout in Appendix 4 . I have presented the data from this source in Appendix 6 with the omission of the mean reaction-times and standard deviations corresponding to each of the digitized settings, and the addition of the overall mean reaction time for each tone-condition. These individual mean RTs were originally called for because it was thought that they would form a symmetrical distribution around the subjective

neutral point. In fact, on inspection, this has not been borne out. No statistical analysis has been carried out to confirm this judgment.

2. Conditioning Sessions

The same comments with regard to individual RT means and SDs apply here, except that the overall mean RT was called for and duly appeared with its corresponding SD.

The data from these printouts form the kernel of this experiment, and I have spent a good deal of time in presenting them in as complete a form as I thought could be desired, and then subjecting them to more and more elaborate analyses; but always with the aim, to adapt a phrase from Samuel Alexander, of "gathering the complexity together and expressing it in a new simplicity".

The first set of tables appear in Appendix 7. These provide, for each subject, virtually all of the gross data which could be culled from the printouts of the conditioning sessions for the whole day. What does not appear here, in addition to individual RTs, is the detailed distributions of errors for the various kinds of trials.

Since it was precisely for this purpose, that the so-called "assessment trials" were introduced, these have been presented, for each subject, in Appendix 8. These tables not only present the basic tone-contingent distributions of R/G responses obtained from the print-out sheets but also derived distributions and statistics which I shall detail below. For the moment, let me state that although these "assessment trials" contain a very great deal of finely dissected information the distributions of responses outside their range (i.e. outside digitized settings 4 through 11) have not been included. The reason for this omission is that since there were 7 times as many "non-reversed" as "reversed" trials for settings 0 through 3 and 12 through 15, to provide a detailed distribution would have been supererogatory: as I have already argued, one cannot, as Howells claimed, make comparisons when the samples differ by a factor of only 7, let alone 19, as in his study. There is no reason, however, why the reader who is interested in the distribution of errors on settings 0-3 and 12-15, considered as separate blocks, could not if he wished, excerpt these from the data presented in Appendix 7 and Appendix 8.

3.14 Quantitative Data

Although the "derived statistics" which appear in Appendix 7 are of such a simple nature that they speak for themselves, this is not so for the distributions derived from the within-session assessment trials presented in Appendix 8.

To understand the genesis of the problem which arose when the raw tone-contingent R/G responses came to be analysed, let us consider the following example:-

<u>Digitized Setting</u>	<u>Responses</u>	
	<u>R</u>	<u>G</u>
4	0	8
5	0	8
6	0	8
7	0	8
8	4	4
9	4	4
10	8	0
11	8	0

We note that if we convert this R/G distribution into a single "chromaticness" distribution, i.e. one in which to each digitized setting a number is assigned which conveys the overall "perceived chromaticity" (irrespective of hue) the distribution becomes:-

<u>Digitized Setting</u>	<u>Chromaticness Score</u>
4	8
5	8
6	8
7	8
8	0
9	0
10	8
11	8

If, on the other hand, we are interested in "perceived achromaticities", the distribution is "inverted", as it were, and becomes:-

<u>Digitized Setting</u>	<u>"Achromaticness" Score</u>
4	0
5	0
6	0
7	0
8	8
9	8
10	0
11	0

I have used the term "achromaticness" to describe these measures. I have not come across this term in the literature⁴, but I can find no reason for not using it in this context.

Looking at this last distribution, it is surely a little disturbing to observe that Q's neutral points stand out so abruptly. We can be reasonably sure that, subjectively, Q does not experience the colours corresponding to these apparently stark distinctions. What we clearly need is some kind of smoothing or interpolation technique which will express our conviction that the distribution of "neutral points" is closer to the gaussian curve than is evident here.

The next and final distribution demonstrates what I consider to be the most obvious manner of achieving this, namely, assigning "achromaticness" scores to the digitized setting boundaries:-

<u>Digitized Setting Boundary</u>	<u>"Achromaticness" Score</u>
4.5	0
5.5	0
6.5	0
7.5	4
8.5	8
9.5	4
10.5	0

This method of analysing the original dichotomous data gives us, I submit, not only a reasonably smooth distribution of Q's subjective "neutral" points, but one which would seem to make subsequent statistical analyses fairly straightforward. This, at any rate, is how I proceeded, not only for the assessment trials but also for the pre- and post-tests, and for similar data in the experiments on the conditioning of gaze-contingent hue responses. Although the description of how this derivation is obtained has been rather long-winded, I should emphasize that the derivation itself can be very quickly achieved in a single mental computation.

The next decision that had to be taken was the measures of central tendency and dispersion to be adopted for these distributions. A glance at most subjects' "achromaticness" distributions in Appendix 8 will indicate that they often deviate markedly from the symmetrical bell-shape that was aimed at. One important reason for this is that we have what is virtually a truncated distribution. Although 4-11 was considered a wide enough spread, it turned out to be insufficient to express all the tone-contingent divergences that actually emerged on analysis. On these grounds, it would seem that the median was the better measure of central tendency than the mean. On the other hand, analyses of the pre- and post-tests showed that some of the tone-contingent differences were so small (and/or the parent distributions so skew) that one obtained results which seemed to reflect opposite tendencies, depending on which measure one adopted. My decision, therefore, was to compute both measures, so that the results could speak for themselves; and I have adopted this procedure throughout.

The measures of dispersion that are customarily associated with the mean and the median are the standard deviation and the semi-interquartile range respectively. I have, however, presented the SDs and the full interquartile ranges. The reasoning behind the latter decision is as follows.

Although Howells was content to accept his critical ratio of 4.1 (which with the large number of degrees of freedom gives a confidence level of $P < .001$) as constituting "reasonable proof that the tones actually exerted a coloring influence upon the visual perceptions", my own experience, when analysing the gaze-contingent data still to be reported, was that a mere index of statistical reliability of, say,

the difference between two means, was not by itself sufficient to convey the significance of the psychological (or rather the psycho-physical) distance between them. What I needed, obviously, was a psychophysical yardstick which could be easily computed for each distribution to be compared. It seemed that an operationally-defined jnd unit was required. I decided on a 50% differential-hue threshold, for which the interquartile range seemed admirably suited. Since, however, the two distributions to be compared (low tone vs. high tone) usually had numerically different interquartile ranges, I took the mean of the two as my J-unit (to give it a neutral, but quite strict definition) which I shall regard, provisionally, as a means of measuring the psychophysical distance between either the means or the medians of the two distributions⁵.

These J-measures are shown in Appendixes 6 and 8 and both the mean and median differences are reported (a) in terms of the "achromaticness" scores, and (b) in terms of the J-units.

The data contained in Appendixes 7 and 8 have been distilled into Table 1. The data of the pre- and post-tests provided in Appendix 6 have likewise been brought together in Table 2.

The graphical representation of all these data provides the final expression of new simplicities from former complexities, and it is to these that we must now turn.

Notes

4. Since this was written, I have found that the term is in fact used by colour-scientists. It will be found in the colour "guide" by Burnham et al. (1963), p. 30, although it receives no specific definition (nor even a mention in the index).
5. Corroboration that the J-unit here defined corresponds to a fairly conservative 50% jnd measure is provided, for example, by Crawford (1969). He says that "colour differences which are just definitely perceptible correspond to about $2\frac{1}{2}$ times the standard deviation". In the case of normal distributions the interquartile range is about $1.35 \times SD$, so that on this basis 1.85 J-units constitute what Crawford calls a JPCS (just perceptible chromaticity shift).

*"achromaticness"

Table 1

Name	STEPHEN	STAN	STEVE	NEVIL	SILKE	JUDAN	EMILY	ERIC	MIKE	Means
Day during which trials carried out, 1972	3 FEB	7 FEB	9 FEB	10 FEB	11 FEB	14 FEB	15 FEB	17 FEB	18 FEB	
Number of 512-trial sessions completed	14½	15	17	16	20	18	18	19½	20	17½
Total number of trials presented	7424	7680	8704	8192	10,240	9216	9216	9984	10,240	8993
No. of 'ruined' trials (too late/early) & % total	147 (1.98%)	86 (1.12%)	162 (1.86%)	196 (2.39%)	126 (1.23%)	427 (4.63%)	459 (4.99%)	267 (2.67%)	151 (1.47%)	225 (2.77%)
Nett number of trials counted	7277	7594	8542	7996	10,114	8789	8757	9717	10,089	8763
Session time range (minutes)	23.4-38.4	14.9-38.4	16.2-38.4	17.1-38.3	16.2-30.3	17.9-35.0	15.0-33.8	15.0-23.8	9.2-21.8	19.14
Total nett duration of day's trials (hours)	6.08	5.58	5.60	5.85	6.05	6.32	5.73	5.48	3.69	5.50
Overall average time per (presented) trial (secs.)	2.95	2.62	2.32	2.42	2.13	2.47	2.24	1.98	1.30	2.24
Mean RT per counted trial per session, range (secs.)	.43-.80	.44-.69	.41-.75	.54-.74	.42-.84	.56-.88	.47-.84	.79-1.16	.47-.86	0.50
Tone duration (prec. colour) spec., range (secs.)	1.0-2.0	.75-1.5	.6-1.5	.5-1.5	.5-1.25	.5-1.00	.01-1.25	0	0	-
Tone + colour duration specified, range (secs.)	1.0-2.0	.75-1.5	.75-1.5	1.0-1.5	1.0-1.25	1.0-1.5	.75-1.25	1.25-1.5	.64-1.25	-
Feedback duration specified, range (secs.)	.50	.4-.5	.3-.5	0-.5	0-.3	.012-1.5	.05-.2	.2-.3	.15-.3	-
Interval between trials specified, range (secs.)	.5-1.5	.25-1.0	.3-1.0	.5-1.0	.4-.75	.5-1.25	.55-1.25	.5-1.0	.35-1.00	-
Feedback pattern employed	25% 100%	0-100%	50%-100%	0-100%	100% (-ve)	0-100%	0-100%	0-100%	100% (-ve)	-
Neutral range(s) specified	8-11, 10-13	5-7, 7-8	-	-	-	-	6-7	6-9	3-10 4-11	-
Midpoint(s) specified	9/10 11/12	6/7, 7/8	6/7, 7/8	6/7	8/9	9/10	6/7	7/8	6/7, 7/8	-
Reversed trials	1.72	0.71	.74	0.73	1.16	1.73	4.36	0.65	1.55	1.49
% LR errors of LR trials counted	0.22	0.71	1.04	0.36	0.96	3.02	3.77	0.50	1.37	1.33
% HG errors of HG trials counted	4.92	5.71	2.05	2.49	2.20	5.91	8.91	2.72	2.74	3.64
% LR errors of LR trials counted	0.09	10.58	4.82	2.94	7.87	3.61	9.73	8.87	2.36	5.65
% HR errors of HR trials counted	1.62	9.55	6.09	18.96	4.02	8.96	15.82	3.67	1.46	7.79
% LG errors of LG trials counted	5.39	11.02	6.88	18.75	5.93	8.49	19.57	3.07	2.32	9.05
% Lg errors of Lg trials counted	30.78	40.5	47.79	16.22	29.72	34.36	51.62	20.48	84.94	39.6
% Hr errors of Hr trials counted	43.78	37.41	44.11	15.29	38.17	31.80	48.27	30.00	77.47	40.7
Ratio of tot. % errors on unsat. conditioning min.	2.54	1.59	2.39	1.13	2.24	3.16	2.48	2.14	3.49	2.35
trials to tot. % errors on unsat. 'reversed' max.	24.75	13.75	55.17	20.00	11.96	14.80	11.86	10.30	∞	20.33(1.46)
Trials (including 'neutral' trials) mean	8.99	5.57	20.97	7.75	7.33	7.78	6.07	4.77	-	8.60
mean 'sample size' ('achromatness' index) LOW	0	27.07	25.47	11.81	25.75	21.78	25.00	22.69	-	22.92
mean 'sample size' ('achromatness' index) HIGH	0	26.67	20.00	15.19	18.45	17.06	24.33	20.55	-	20.33
mean 'sample size' ('achr.' index) LOW + HIGH	0	26.87	22.74	13.50	22.10	19.42	24.67	21.74	-	21.58
mean interquartile range for LOW	0	2.41	2.13	1.28	2.40	1.95	2.91	2.19	-	2.16
mean interquartile range for HIGH	0	2.17	1.75	1.81	1.63	1.63	2.56	1.77	-	1.90
mean interquartile range for LOW + HIGH	0	2.29	1.94	1.55	2.02	1.79	2.74	1.98	-	2.04

Table 2

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES

SUBJECTS	PRE-TEST(S)				POST-TEST(S)				NETT DIFFERENCES			
	VERBAL	P (2-tailed)	KEY-PRESS	P (2-tailed)	VERBAL	P (1-tailed)	KEY-PRESS	P (1-tailed)	VERBAL	P (1-tailed)	KEY-PRESS	P (1-tailed)
STEPHEN	-		-.140	.507 n.s.	-		+.889	.00025 ***	-		+1.029	.018 *
STAN	-		+.390	.149 n.s.	-		+.590	.0005 ***	-		+0.200	.268 n.s.
STEVE	+.097	.730 n.s.	-		+.198	.198 n.s.	+.724	.000003***	+.101	.369 n.s.	(+.724)	
NEVIL	-.386	.189 n.s.	-		-		+1.630	.0023 **	-		(+1.630)	
SILKE	-.439	.179 n.s.	-		+.359	.098 n.s.	-		+.798	.039 *	-	
JOAN	-.337	.300 n.s.	-		+.562	.035 *	-		+.899	.029 *	-	
EMILY	-.329	.130 n.s.	-		-.288	.062 n.s.	-		+.041	.491 n.s.	-	
ERIC	-		-		+.537	.022 *	-		(+.537)		-	
MIKE	-		-		(-.242)		unanalysable		(-.242)		-	

SUMMARY RESULTS FOR TONE-CONTINGENT DIVERGENCES ON PRE- AND POST-TESTS EXPRESSED AS MEAN J-UNIT DIFFERENCES

$P > .05$ n.s.
 $P \leq .05$ *
 $P \leq .01$ **
 $P \leq .001$ ***
 + = predicted direction
 - = direction opposite to that predicted
 (on the basis of conditioning having occurred)

SUBJECTS	PRE-TEST(S)				POST-TEST(S)				NETT DIFFERENCES	
	VERBAL	P (2-tailed)	KEY-PRESS	P (2-tailed)	VERBAL	P (1-tailed)	KEY-PRESS	P (1-tailed)	VERBAL	KEY-PRESS
STEPHEN	-		-.047	.99 n.s.	-		+.561	.021 *	-	.608
STAN	-		+.276	.165 n.s.	-		+.444	.075 n.s.	-	+.168
STEVE	+.123	.729 n.s.	-		+.177	.359 n.s.	+.1006	.0015 **	+.054	-
NEVIL	-.428	.178 n.s.	-		-		+.799	.0038 **	-	-
SILKE	-.280	.671 n.s.	-		+.601	.065 n.s.	-		+.881	-
JOAN	-.196	.718 n.s.	-		+.640	.099 n.s.	-		+.836	-
EMILY	-.124	.740 n.s.	-		-.359	.079 n.s.	-		-.235	-
ERIC	-		-		+.221	.140 n.s.	-		-	-
MIKE	-		-		-		unanalysable		-	-

SUMMARY RESULTS FOR TONE-CONTINGENT DIVERGENCES ON PRE- AND POST-TESTS EXPRESSED AS MEDIAN J-UNIT DIFFERENCES

3.15 Graphical Representation: The Plan Adopted

An attempt has been made to graph the data in a series of progressively more refined steps. The bulk of these presentations are to be found in Appendix 9, where separate space has been allocated to each subject. In this section I have abstracted and brought together what I consider to be those elements most salient to the hypothesis under scrutiny.

The progression begins with the analysis of errors, in gross, on reversed unsaturated trials, $Hr(i)$ and $Lg(j)$. This corresponds to the way Howells presented his data, Fig. 1, p.53, except that his graphs include errors on reversed saturated trials, HR and LG, whereas it would have been logically indefensible to do so in my case since Q's task, when R or G were presented, was to "ignore" the hue and respond to the sound.

Having argued previously that Howells' exclusion of errors on non-reversed (i.e. "conditioning") trials was a mistake, the next step is naturally to present these in juxtaposition with "reversed" errors (this time excluding LR and HG, of course) so that a meaningful comparison could be made.

These curves cover "gross" errors, by which I mean errors which globally encompass the whole range of 16 unsaturated colours. The next refinement was to see how these errors were disposed with respect to differentials of chromaticity (and tone-contingencies). It was for this very reason that the "within-session assessment trials" were introduced. The tables analysing these in Appendix 8 give us the tone-contingent divergences in terms of both means and medians, of the "achromaticness" scores; and they have accordingly been graphed for each subject (on the same axes, of course) over his day's sessions.

Since O's tone-contingent divergence for a given session, does not take into account his own variability or scatter or oscillation within that session, we need to express these tone-contingent differences in a way which does. On the assumption that the previously defined J-unit will serve as a scale interval for this purpose, the next move was to graph these J-unit differences (for both means and medians) in parallel with the "achromaticness"-score plots, and on their own.

A still further elaboration was suggested after the final J-unit curves for each O were inspected and related to his pre- and post-test results. An account of this (final) manoeuvre will have to await the (following) analysis and interpretation of the data.

3.16 Graphical Data: Preliminary Inspection and Evaluation

Fig. 3 presents a comparison, for the first four subjects (the only ones who wore attenuating or occluding goggles outside the experimental situation) of reversed and non-reversed unsaturated errors over the day's sessions. The same is done in Fig. 4 and Fig. 5 for three and two subjects respectively.

Examining these curves, one is struck by the fact that of the nine subjects, only two, Mike and Emily, seem to show the kind of increase in reversed-trial errors that would lead one to expect the manifestation of the Howells-effect; that is a post-experimental tone-contingent change in colour perception such that $L \rightarrow R$ and $H \rightarrow G$. In fact, referring to Table 2, p.118, they are the only two whose scored test results show a shift in the direction opposite to that predicted!

In the absence of additional evidence, we might justifiably conclude that the hypothesis generated by the behavioural theory has been disconfirmed.

If we take into account the concomitant curves for errors on non-reversed trials, such a conclusion would be strongly reinforced in the case of Mike, because whereas his reversed-trial errors virtually reach 100%, his "normal" or conditioning trial errors go down to an effective zero.

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF PROPORTION OF ERRORS, EXPRESSED AS A PERCENTAGE, (a) OF "REVERSED" UNSATURATED TRIALS, AND (b) OF "NON-REVERSED" UNSATURATED TRIALS.

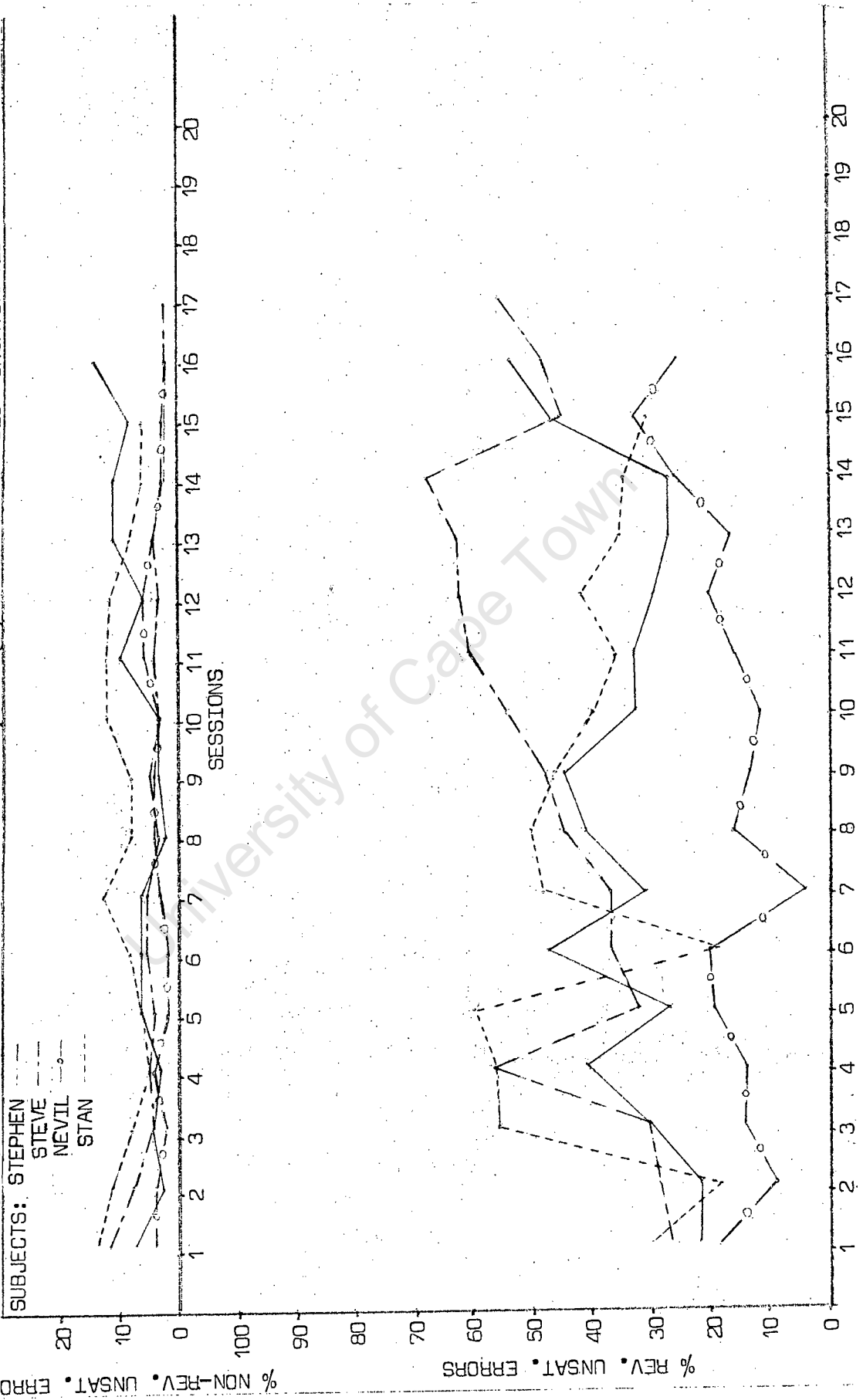


Figure 4

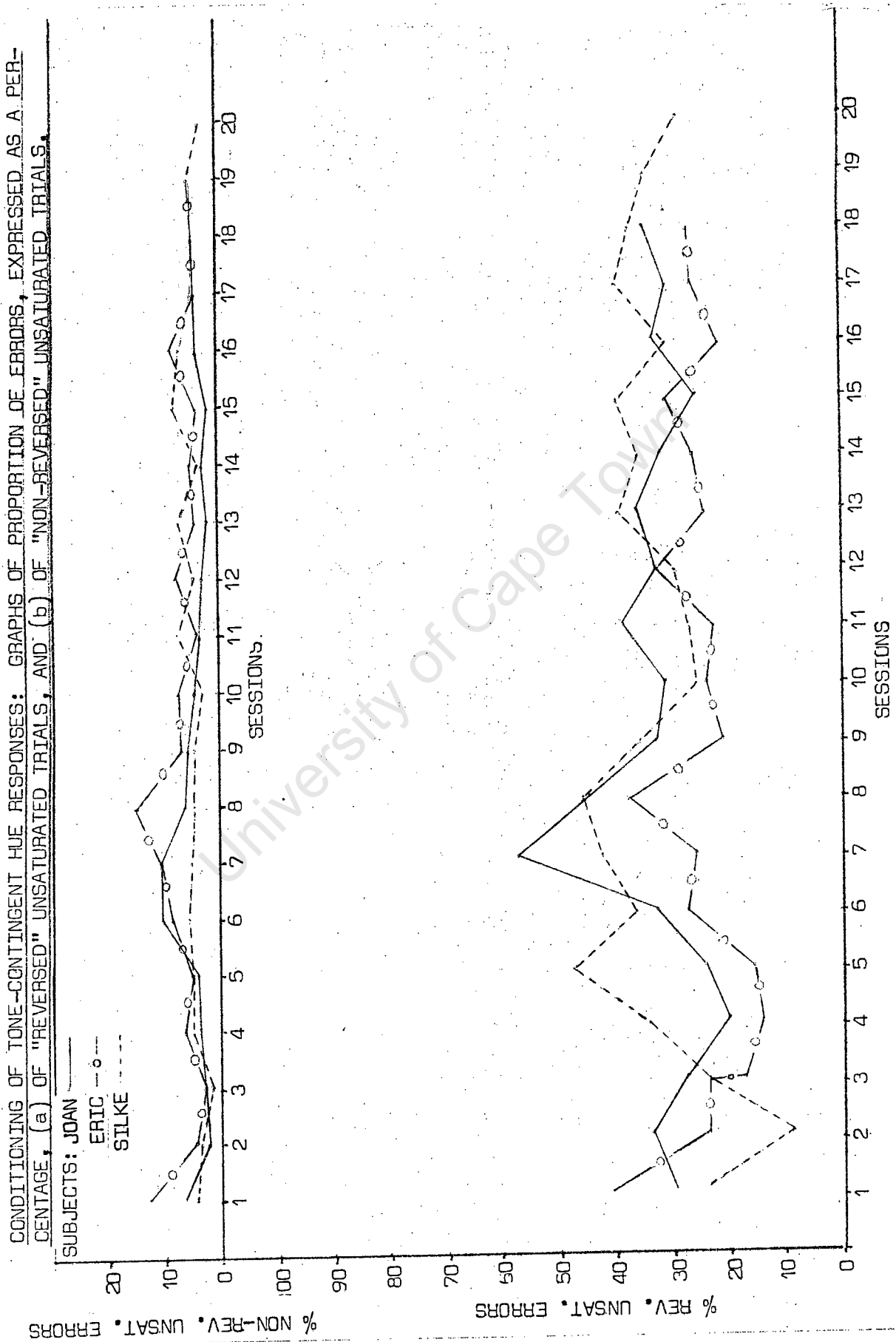
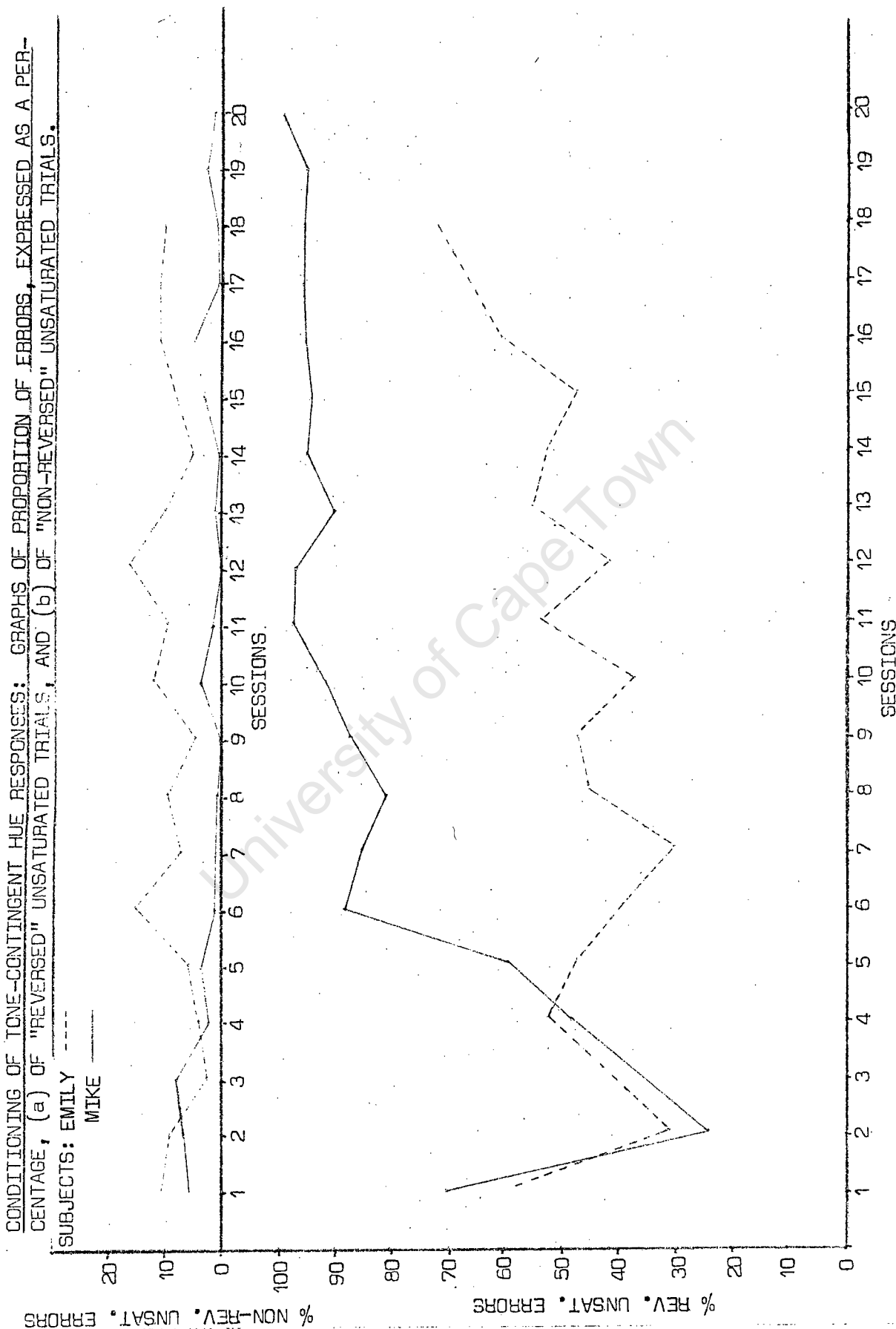


Figure 5



Emily's case is not so straightforward, however, since her non-reversed errors oscillate around the 10% mark, which, from Table 1, p.113, is about twice the overall average and the largest of all nine subjects. There is, at this stage, no reason to doubt that Mike's results constitute a counterinstance, but the case of Emily is already problematical.

Turning to the corresponding plots for the other seven subjects, we find that the slope of the curves of reversed errors for Silke, Joan and Eric (Fig. 4) appears to be zero (after the 9th or 10th session, at any rate), at about the 30% mark, compared to a maximum of 70% for Emily and 99% for Mike. There seems little justification to expect the Howells-effect with these subjects, even though their non-reversed errors plateau at only about 5%.

In the case of Stephen, Stan, Steve and Nevil (Fig. 3) it is more difficult, by mere visual inspection, to pick out any clear trends. Stephen's reversed-error rate begins to rise only in the last two sessions, but this seems to be nullified by his high non-reversed errors. Stan's reversed-error curve actually has a negative slope from session 8 onwards. Steve's curve rises steadily from the 7th to the 14th session and then falls again. Nevil's error-rate seems to be the lowest of all subjects, even though there is a positive slope from sessions 7 to 15. Turning to the non-reversed errors, however, we see that Nevil and Steve show a consistently low rate (between 1% and 5%).

The picture thus far is a confusing one: it is to the assessment trials that we must turn for clarification.

It was found that to plot the dual (L vs. H) "achromaticness" means or medians for more than one subject on the same axis was visually quite confusing; I must therefore refer the reader to Appendix 9. There is no need to spend much time in discussing these curves. Nearly all subjects show a more-or-less fluctuating differential. It is difficult to discern a clear case of increasing tone-contingent differences for anyone except Steve (p.294 and p.302). Mike's results become unanalysable after the fifth session because his mid-points move right out of the 4-11 range.

We turn, therefore, to the J-unit graphs. I have shown these on p. 126a & b, Fig. 6 (A-D & E-H), for eight subjects. (In Stephen's case there were no comparable assessment trials, only half the number of presentations per digitized setting having been included.)

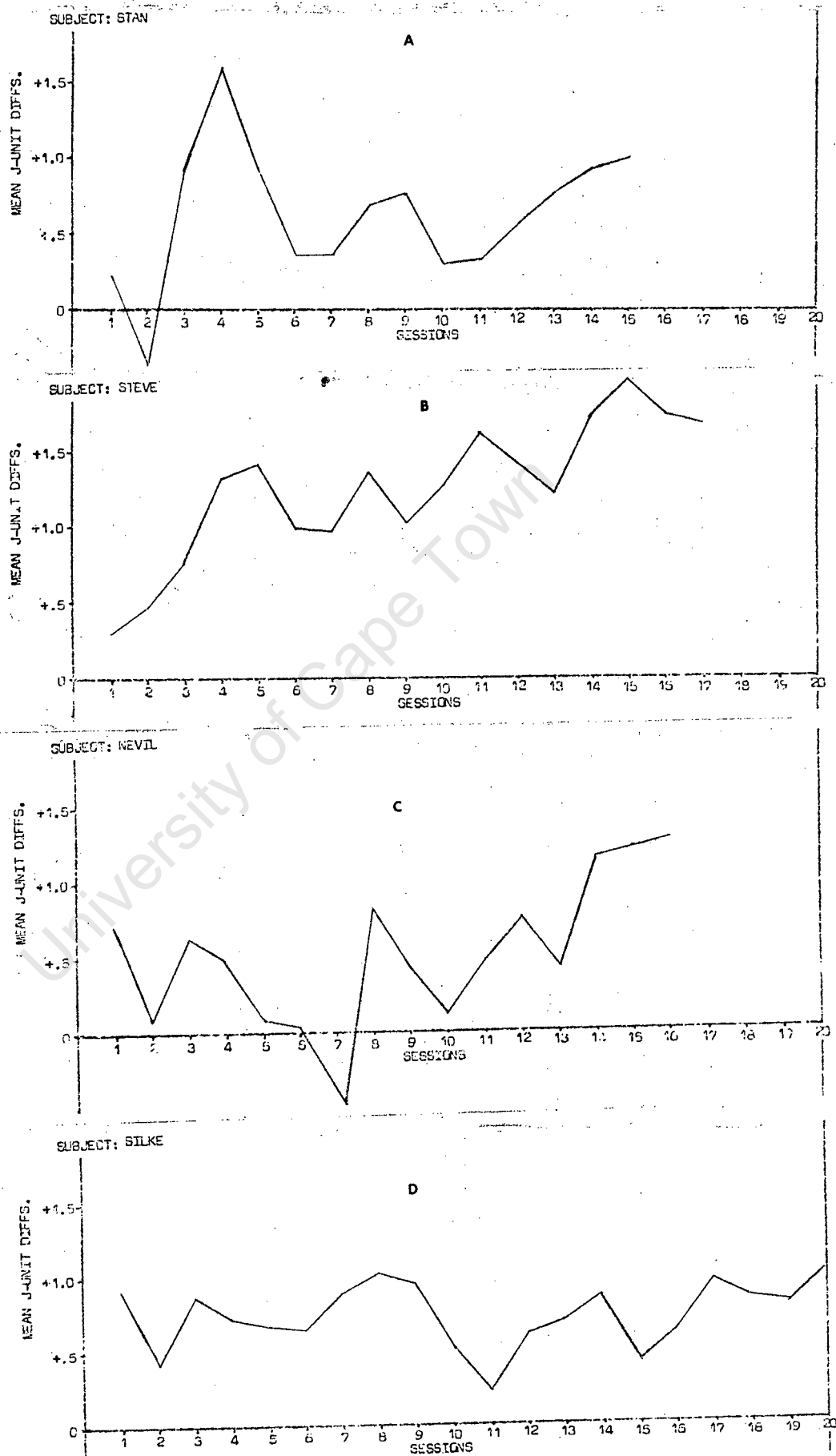
Emily (Fig. 6 F) deserves our first attention. At once we see that whereas her reversed errors (Fig. 5) showed a gradual and substantial rise, her tone-contingent mean differences expressed in J-units are highly erratic and, from session 13, actually have a negative slope! A clearer case for the need of our assessment trials and their translation into J-unit differences could hardly be required.

Although Mike's J-unit curve could not be extended beyond the 5th session, this does not prevent us from assessing its probable course had the assessment trials possessed a wider range. To be quite conservative, if we suppose that his mean "achromaticness" scores eventually reached $g(3)$ under the influence of L, and $r(12)$ under the influence of H (since $L \rightarrow R$ and $H \rightarrow G$), we obtain a difference of about 4.5 J-units. Since the nett time for Mike's sessions was only 3.7 hours (for reasons that will be made clear later) this would constitute a quite remarkable result. To anticipate, the largest tone-contingent shift actually shown in these curves was that of Steve, and amounted to no more than 2 J-units. The largest after-effect hue shift contingent on alloretinal afferents in this whole study was not more than 3 J-units—after 14.9 hours of nett training time. Mike's results, at this stage, are quite unintelligible.

Examine now the J-unit mean differences for Silke, Joan and Eric, in D, E & G. There are individual differences, especially in the pattern of fluctuation, but no distinct positive slope emerges for any of them.

In the case of Stan, Steve and Nevil (A, B & C), however, things look quite different. Although there is a large measure of fluctuation in the beginning, from about the 10th session it tends to iron out and there is a perceptible positive slope. If, in these three cases we should get negative post-test results, then the behavioural hypothesis would be virtually impossible to sustain.

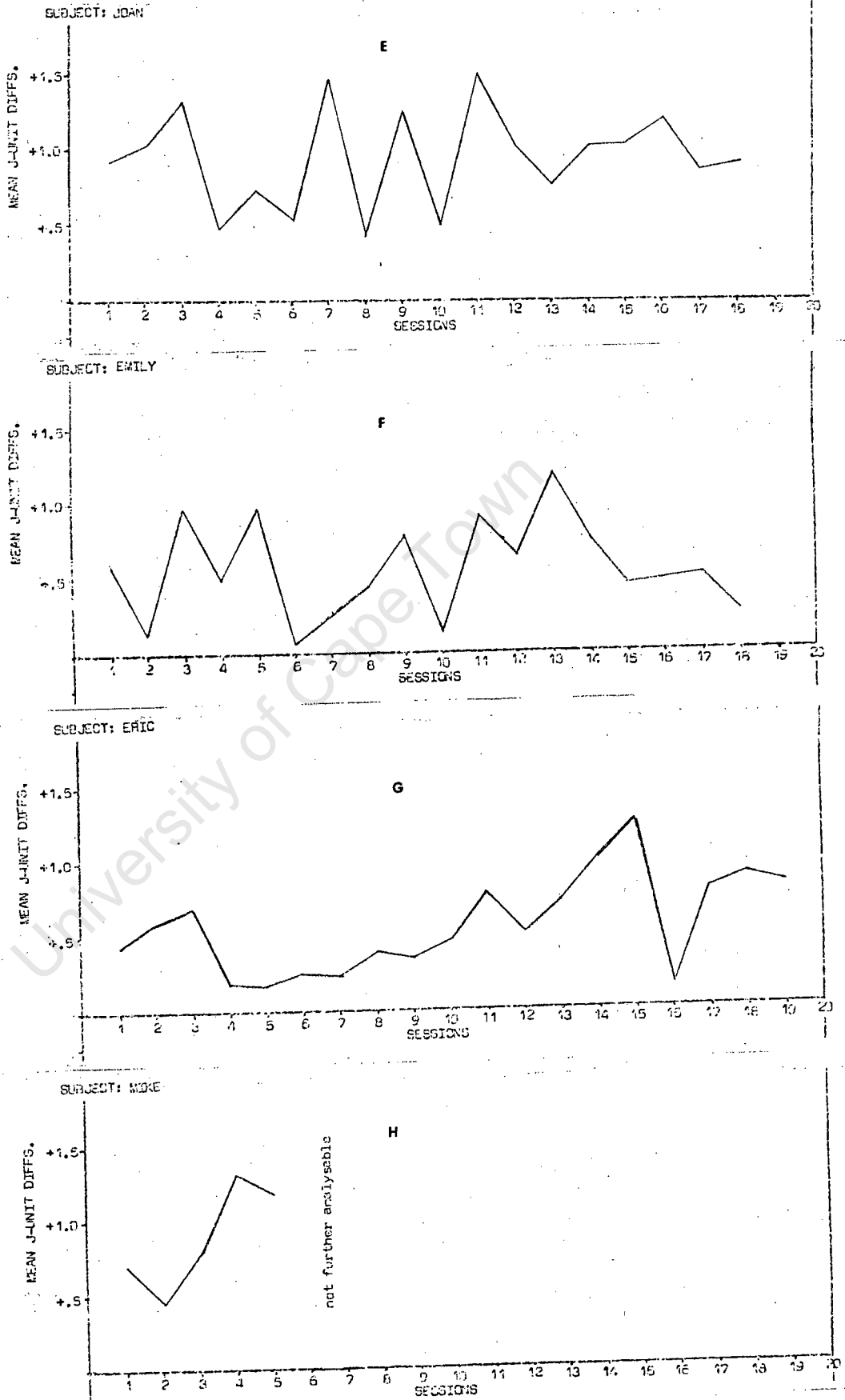
Figure 6 (A - D)



CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: ASSESSMENT TRIALS

Mean J-Unit Tone-Contingent Divergences for Four Subjects

Figure 6 (E - H)



CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: ASSESSMENT TRIALS

Mean J-Unit Tone-Contingent Divergences for Four Subjects

Before turning to the test-results themselves, a final development of the J-unit data suggested itself, namely, curve-fitting.

Using a linear regression model as a first approximation, it was hypothesized,

- (a) that the tone-contingent divergences over a whole day's sessions for a given subject could be divided into two roughly equal sections, namely,
- (b) an initially unstable phase to which no straight line whose slope was significantly different from zero, could be fitted,
- (c) a second phase, say from trial 10 onwards, which would differ from subject to subject in terms of the size, direction and stability of the slope of the best-fit straight line.
- (d) that the pre- and post-test results for each subject could be correlated with either the best-fit straight line for the whole day's sessions, or the best-fit straight line mentioned in (c), or both.
- (e) that the straight line fitted to the data for sessions 10 onwards could be used as a predictor which would allow E to select those subjects who are likely to be most easily amenable to training in future work of this kind.

These three regression equations ($y = ax + b$) were accordingly calculated.

Hypothesis (a) was largely confirmed. Except for Steve, none of the correlations between session number and J-unit mean difference was significant at the 5% level, and the slopes of nearly all were effectively zero.

Table 3 provides parameters of linear regression equations fitted to (i) the mean, and (ii) the median J-unit tone-contingent divergencies for each subject over (a) a full day's sessions (1 to N), and (b) over sessions 10 to N; and (c) the predicted values for $N = 40$

CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: ASSESSMENT TRIALS

Parameters of Linear Regression Equations Fitted to (i) Mean, and (ii) Median

J-Unit Tone-Contingent Divergencies Over Full Day's Sessions (N),

and Over Sessions 10 to N; and Predicted Values for N = 40

Subjects	N	Slope (a)		Intercept (b)		Corr. Coeff. (r)		Sign. Level		Predicted J-unit Diff. at N = 40
		Session Range		Session Range		Session Range		of r (10 to N)		
		1 to N	10 to N	1 to N	10 to N	1 to N	10 to N	P		
Stephen	14					not done				
Stan	15	+0.023	+0.157	+0.439	-1.315	+0.230	+0.982	.0005	***	+4.965
Steve	17	+0.077	+0.067	+0.540	+0.674	+0.841	+0.646	.14	n.s.	+3.354
Nevil	16	+0.040	+0.189	+0.256	-1.686	+0.424	+0.908	.007	**	+5.874
Silke	20	+0.0037	+0.055	+0.099	-0.135	+0.099	+0.738	.056	n.s.	+2.053
Joan	18	+0.0075	+0.0039	+0.871	+0.930	+0.120	+0.038	.94	n.s.	+1.065
Emily	18	-0.00042	-0.036	+0.557	+1.088	-0.007	-0.323	.52	n.s.	-0.349
Eric	19	+0.029	+0.023	+0.271	+0.405	+0.525	+0.220	.66	n.s.	+1.325
Mike	20					unanalysable				
+ = predicted direction - = opposite direction P > .05 n.s. P ≤ .05 * P ≤ .01 ** P ≤ .001 *** (Two-tailed)										
Subjects	N	Slope (a)		Intercept (b)		Corr. Coeff. (r)		Sign. Level		Predicted J-unit Diff. at N = 40
		Session Range		Session Range		Session Range		of r (10 to N)		
		1 to N	10 to N	1 to N	10 to N	1 to N	10 to N	P		
Stephen	14					not done				
Stan	15	+0.024	+0.148	+0.429	-1.223	+0.199	+0.963	.002	**	+4.697
Steve	17	+0.089	+0.063	+0.537	+0.885	+0.823	+0.517	.272	n.s.	+3.405
Nevil	16	+0.030	+0.190	+0.221	-1.859	+0.355	+0.989	.011	*	+5.741
Silke	20	-0.00030	+0.063	+0.652	-0.377	-0.006	+0.683	.095	n.s.	+2.143
Joan	18	+0.022	+0.023	+0.855	+0.873	+0.311	+0.181	.724	n.s.	+1.793
Emily	18	+0.0048	-0.048	+0.620	+1.400	+0.074	-0.395	.418	n.s.	-0.520
Eric	19	+0.022	+0.016	+0.251	+0.374	+0.436	+0.176	.730	n.s.	+1.014
Mike	20					unanalysable				

(i)

Mean
J-Unit
Diffs.

(ii)

Median
J-Unit
Diffs.

(i)
Mean
J-Unit
Diffs.(ii)
Median
J-Unit
Diffs.

(i.e. after about 20,000 trials would have been administered).

From this table, one can, I am arguing, rank subjects in terms of their susceptibility to the Howells after-effect. The criteria to be used are the slope and intercept of the two equations and the values and significance level of the correlation coefficients, especially that for sessions 10 to N.

By inspection, I would say that the medians are less reliable predictors than the means, and that using the data for the latter I would rank subjects in the following (descending) order:-

1. Nevil
2. Stan
3. Steve
4. Silke
5. Eric
6. Joan
7. Emily

Stephen and Mike have, of course, (for different reasons) to be excluded.

We turn to Table 2 now, which is a distillation of the full analysis of the actual pre- and post-training test results presented in Appendix 6. By inspection of the mean J-unit tone-contingent differences on (a) the pre-tests, (b) the post-tests, and (c) the nett differences between these differences in terms of direction, size and statistical reliability, I would rank subjects in the following order:-

1. Nevil
2. Steve
3. Stan
4. Eric
5. Silke
6. Joan
7. Emily

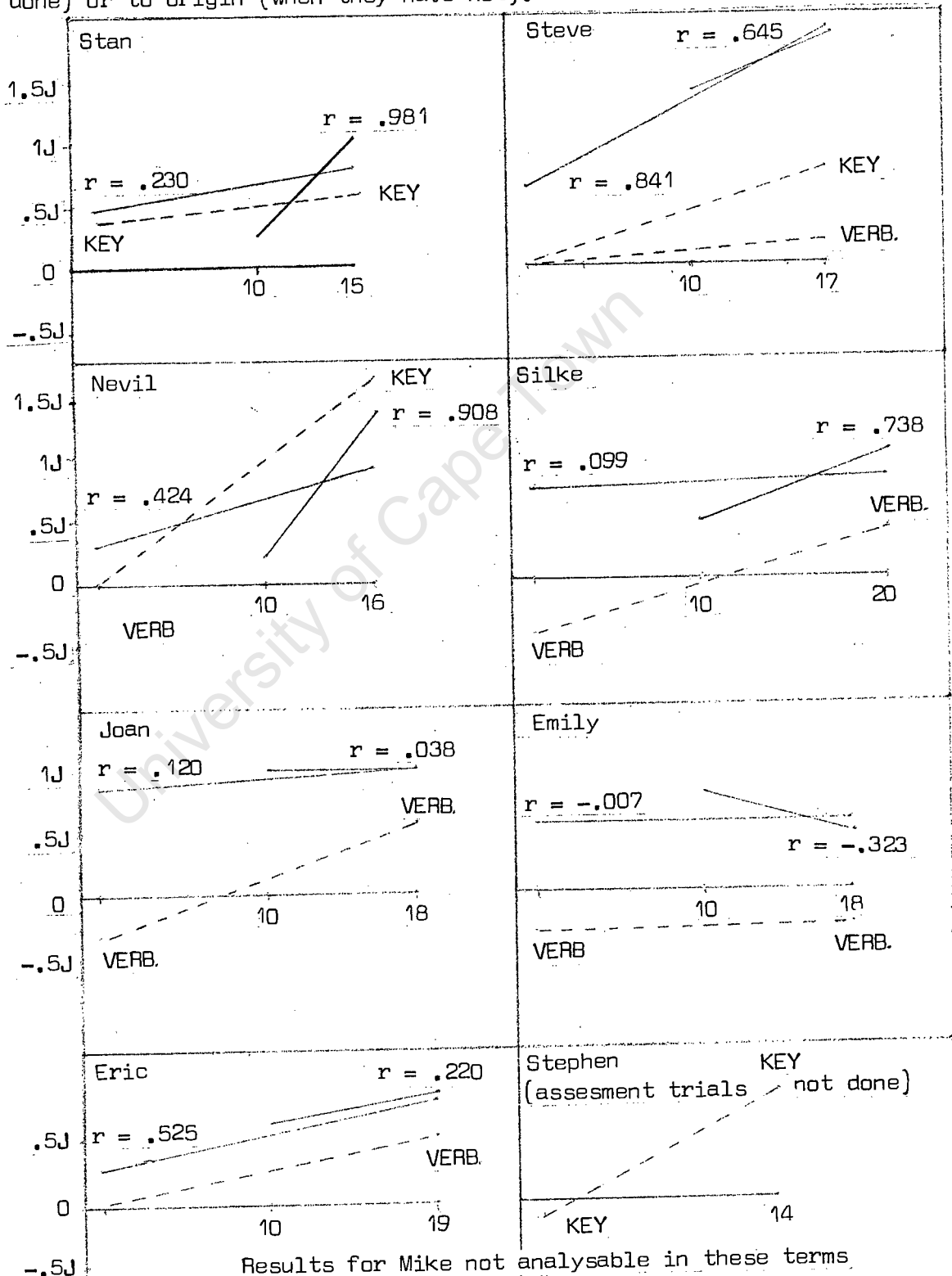
A comparison of these two rankings using Spearman's rank-difference correlation technique, yields a coefficient of $\rho = 0.93$.

Looking more closely at the summary test results in Table 2 we note that in spite of the smallness of the tone-contingent divergences, they are all (with the exception of Emily and Mike) in the

predicted direction; and of the remaining seven subjects, the results of the post-tests of no fewer than five are significant (using a two-tailed t-test) at better than the 5% level. Since, we are, however, making a specific prediction concerning the direction of these shifts, we are fully entitled to use a one-tailed test, and on this basis we can include Joan's post-test results and Silke's nett difference results to the list of $P < .05$ levels of significance, leaving only Emily and Mike as odd men out.

Before we consider individual subjects, especially the cases of Emily and Mike, I should like to present the reader with the final graphical representation of the course of the whole tone-contingent experiment for each of the subjects except Mike. Fig. 7 links the test data of Table 2 with the regression curves in Table 3 and serves as a final abstraction and condensation of all the data presented in Appendixes 7, 8 & 9.

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: FINAL GRAPHICAL REPRESENTATION OF RESULTS FOR 8 SUBJECTS OVER DAY'S SESSIONS, 1 to N. Solid lines represent linear regression curves of J-unit mean tone-contingent divergences on assessment trials for (a) sessions 1 to N, and (b) sessions 10 to N. Dotted lines join post-test J-unit mean tone-contingent divergences to corresponding values for pre-tests (when these have been done) or to origin (when they have not).



Note: "KEY" indicates a verbal-cum-key-pressing response
"VERB." indicates a purely verbal response

3.17 Three Subjects: A Critical Examination

Taylor's methodology seeks to combine the nomothetic with the idiographic approaches. Armed with a general law or a set of general equations about all human organisms, the investigator can substitute for the parameters of the equations the values found for the individual organic system with which he is for the moment concerned. The law must be completely universal, yet it must also be able to predict "individual differences" to the last detail, provided the necessary substitutions can be made. If a blatant departure from our theoretical postulates seems to be operating, we must establish that we have not omitted a known parameter, or alternatively that an unknown parameter is operating which we did not or could not specify. If we fail to find such evidence, or, more strongly, if the values we previously assigned are confirmed in every respect, then a departure from the prediction renders the law as such suspect.

In the light of the above the case of Mike must be considered first. Of all 9 subjects, his are the only results which are patently anomalous.

Consider, first of all, some personal data.

Mike had normal colour discrimination: his Farnsworth-Munsell profile is reproduced in Fig. 8 . His hearing was not tested, but that it was not defective was proved by subsequent events. He had

Figure 8

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: REPRODUCTION OF
FARNSWORTH-MUNSELL 100 HUE TEST FOR NINTH SUBJECT

Name Mike Age 24 Date 12/1/72

85	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85

Lab..... Exp.....

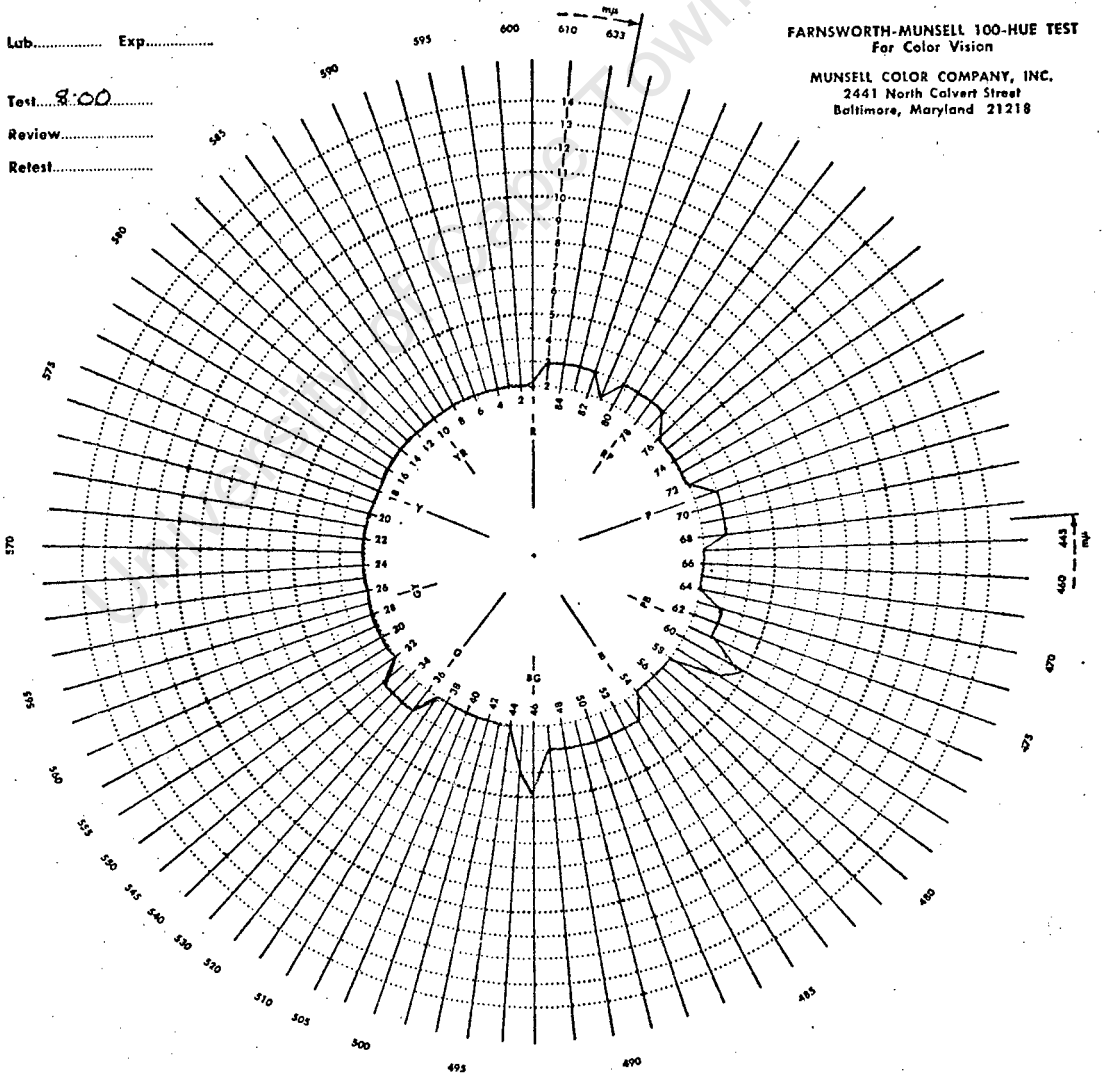
Test 8:00

Review.....

Retest.....

FARNSWORTH-MUNSELL 100-HUE TEST
For Color Vision

MUNSELL COLOR COMPANY, INC.
2441 North Calvert Street
Baltimore, Maryland 21218



completed first year courses in three subjects, including psychology, from which we can infer that his intelligence was likely to be at least "bright-average". I established that he was very keen in excelling in tasks where superior physical fitness and/or mental alertness were called for. He showed throughout the day a splendid conscientiousness in his attitude towards the task: his motivation was not in question.

From the above, I am satisfied that Mike was, and is, an excellent prospective subject for any experiment involving the attempted disruption of ultrastability.

Let us turn our attention to the experimental setting. Mike was my last subject. I had before me the test data (in raw form) of the previous eight subjects, and they were, to say the least, undramatic. There seemed little to lose in opting for a drastic change of strategy. Silke Vogelmann (1971, 1972) had used an operant shaping technique with startling, if not easy to interpret, results. Her method was to provide a positive feedback (within a range of unsaturated colours) when Q responded to the tone (in accordance with $L \rightarrow R$ and $H \rightarrow G$) irrespective of the colour, although in most cases colour and tone were congruent. My own programme was such that Q had to react this way to saturated colours, but not to unsaturated colours, where he could succeed only by ignoring the tone.

Not being conversant with more than the basic principles of operant techniques, I took counsel with other members of the teaching staff and finally decided on the following policy. After ensuring that he was able to solve the puzzle, I would gradually widen the so-called "neutral-range" (i.e. that central series of unsaturated colours on which no feedback was provided), while maintaining a 100% (negative) feedback pattern on all other trials (after the second session). In contrast with my other subjects, I decided to keep our verbal interactions to the barest minimum, as follows:-

1. I read the instructions for the main experiment (no pre-test was performed).

I asked him to describe the nature of the puzzle after it was clear that he had solved it, particularly noting that he understood that he was to react to the hue in the case of the unsaturated colours.

3.17 Three Subjects

2. I asked him to name the colours that were being presented and he mentioned "pale pink", "pale green" and "grey"; as well as "dark green" and "dark red".

3. In contrast with other subjects, I did not give him within-session feedbacks in terms of overall percentage of correct responses. I merely told him whether his performance was adequate or not, whether it was getting better or worse, and also whether the number of ruined trials was excessive.

4. There was no post-session de-briefing. After establishing that he understood the task and saw the colours veridically, I never asked him about his experiences as I did with all other subjects.

Concomitant with the widening of his neutral range, I gradually tightened all time parameters, until he was responding at the rate of 56 trials per minute! (Howells' rate was about 9 trials per minute. The overall average of my other subjects was 25 trials per minute).

The results I have presented so far speak for themselves. What I have not discussed is the result of his post-test (for which he was given no special instructions and in which he was not required, as was the case with all other subjects performing a key-pressing test, to say aloud the colour he saw as he made his motor response). The computer printout of this test is reproduced in Table 4. The results were 100% perfect: every chromatic stimulus paired with L was responded to by pressing the left-hand key (which corresponded to "red" in the experimental task) and every stimulus paired with H was responded to with the "green" key. I have said all along that these results are "unanalysable". This, of course, needs qualification. They are unanalysable only in terms of the "achromaticness" scores which I had devised and used with all other subjects: there was simply no "neutral point". But had I used another assessment technique, viz.

$$\frac{\Sigma(L \rightarrow R) + \Sigma(H \rightarrow G)}{\Sigma(L + H)}$$

where, e.g., $\Sigma(L \rightarrow R)$ = no. of trials in which a low tone led to a left key-press.

his score would have been the theoretical maximum, and had I simply paid him his R10.00 and dismissed him at the completion of this test,

DATE: 18 FEB POST (KEY-PRESS)

SUBJECT: MIKE

NEUTRAL RESPONSE - YES(1), NO(0): 0

TIMET TIMEC TIMEP
2 640 360

BLOCT BLOCN NBLOC
16 2 8

PAUSE

STIM		NO TONES					LOW TONE					HIGH TONE				
		R	G	N	AV	SD	R	G	N	AVE	SD	R	G	N	AVE	SD
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	16	0	0	0	0	0	8	0	0	496.	37.	0	8	0	473.	21.
1	16	0	0	0	0	0	8	0	0	446.	16.	0	8	0	497.	28.
2	16	0	0	0	0	0	8	0	0	469.	9.	0	8	0	490.	22.
3	16	0	0	0	0	0	8	0	0	503.	61.	0	8	0	475.	13.
4	16	0	0	0	0	0	8	0	0	482.	14.	0	8	0	499.	47.
5	16	0	0	0	0	0	8	0	0	500.	44.	0	8	0	505.	22.
6	16	0	0	0	0	0	8	0	0	489.	52.	0	8	0	493.	51.
7	16	0	0	0	0	0	8	0	0	487.	24.	0	8	0	488.	39.
8	16	0	0	0	0	0	8	0	0	477.	32.	0	8	0	468.	27.
9	16	0	0	0	0	0	8	0	0	516.	42.	0	8	0	474.	24.
10	16	0	0	0	0	0	8	0	0	497.	29.	0	8	0	494.	18.
11	16	0	0	0	0	0	8	0	0	465.	12.	0	8	0	471.	25.
12	16	0	0	0	0	0	8	0	0	560.	33.	0	8	0	467.	22.
13	16	0	0	0	0	0	8	0	0	477.	47.	0	8	0	529.	40.
14	16	0	0	0	0	0	8	0	0	502.	27.	0	8	0	485.	36.
15	16	0	0	0	0	0	8	0	0	482.	24.	0	8	0	489.	63.

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: COMPUTER PRINTOUT OF
POST-TEST FOR NINTH SUBJECT

I could point to his "cumulative record" (as enshrined in 21 sheets of TTY printout) as an example of a completely successful essay in "perceptual shaping".

I did not stop at that point, however. I administered an informal (but perfectly adequate) test in which he had merely to say whether a given visual stimulus (accompanied by either L or H) was chromatic or achromatic. His actual verbal response on a given trial was "colour" or "no colour". The results are to be found in Appendix 6, p.267, from which it is clear that although there may have been some kind of "bleaching" effect, it was certainly not tone-contingent--except very slightly in the direction opposite to that predicted.

Finally, a test was performed which took no more than 10 seconds to administer. It is the kind of test one can perform only on an organism whose repertoire includes those forms of behaviour sometimes referred to as "language":-

E: "In the key-pressing test that you did about 15 minutes ago, did you respond to the colours or the sounds?"

O: (looking rather shame-faced) "The sounds".

Further comment on Mike's data would be supererogatory.

We must now look at Emily. Whereas Mike's results might have been construed as posing a threat to the behavioural theory, Emily's results were quite in keeping with that theory. All we have to explain is her poor performance, considering that she was a highly intelligent girl with good colour-discrimination, and apparently well-motivated.

The explanation is simple. Emily had gone to bed at 3 a.m. that morning and had had less than 4 hours sleep. In addition, she was "almost totally deaf" in her left ear. She bravely tried to keep up with the demands that were made on her (and even practised her yoga exercises in between sessions), but to no avail. Her behaviour (and her perception) were "noisy". "The colours are swimming into each other"--and so were her responses, which is another way of saying that she performed with less than adequate coherence and consistency.

The only other subject I wish to mention here is Silke. Silke's results are in many ways the most significant of all. Because, in spite of (a) her understanding of the overall experimental aim, (b) her detailed knowledge of the technique I was employing and its specific contingencies, and (c) that it was understood that she was to actively resist the conditioning process, her nett after-effect tone-contingent hue-shift, although just short of a J-unit, was significant (1-tailed t-test) at $P < .05$. Moreover, she herself fully believed that she had not succumbed in the slightest way to the procedure imposed on her.

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I should like to begin with an examination of the results in terms of Taylor's notions and then go on to deal with experimental design, especially with respect to future research possibilities.

Although Taylor (1958) cites Howells' original study as an example of experimenting on an ultrastable system (Ashby, 1952), I have already indicated why we might be sceptical that it constitutes a paradigm case in the same sense that, say, the wearing of inverting spectacles does. Having directed myself toward the notion of ultrastability, it is necessary to ask whether, and to what extent, its operation was in evidence with my nine subjects.

Before attempting an answer, I should like it to be recalled that the analysis of the data cannot be conducted in terms of a sample of $N = 9$, but rather, we might say, in terms of "nine samples of $N = 1$ ". I have already argued that Taylor's nomothetic/idiographic approach demands this; we must see how it works out in practice.

The first requirement is that the subsystem of the organism being studied should be put into a "critical state" (which can be thought of as a condition of disequilibrium or arousal). If this cannot be done, or if the critical state is a very minor one, it will obviously be difficult or impossible to demonstrate ultrastability. The "puzzle-environment" maintained by the computer was intended as the "primary operation" which would put O into this initial state of disequilibrium.

There was at least one subject of whom it could be said that this initial condition was certainly not met, and that was Eric. As I have mentioned, Eric mastered the task very quickly indeed and by the end of the first session he was clearly bored. Since I had no more puzzles up my sleeve, I had to try and bring about a new and different critical state. I did this by (a) asking him to name the colours as he pressed the keys, providing a third negative feedback signal when his naming responses were discrepant with his key-pressing responses, and (b) by making the time parameters so brief that his task became very difficult indeed. This was manifestly a blunderbuss policy and it produced stress effects similar to those reported by Howells. I have already described his symptoms. He was the only subject for whom the experiment was a gruelling, even nerve-racking experience.

An examination of Table 2, p.118, will show that Eric's result was really quite slender even though it was in the predicted direction (and reliably so).

I would formulate the hypothesis (taking the results of Howells' subjects into account as well as Eric's) that a property of the multi-stable system apparently not envisaged by Ashby, is that failure of a subsystem in a critical state to change to a non-critical state when a primary operation is applied does not necessarily betoken that the system is not ultrastable. Since for Ashby the process of transforming an initially unstable into a stable system is called adaptation, we can go on to hypothesize that the same subsystem can at one and the same time display properties that are both adaptive and maladaptive.

Applying the hypothesis to the human organism, one condition which seems to satisfy this dual state of affairs is, I submit, neurosis. For example, the agoraphobic solves her problem (and fails to solve it) by staying at home. But neurosis is not the only condition which will satisfy it. The inmate of a prisoner-of-war camp who defies the orders of a callous officer and refuses to bend to the demands of an irrational system, will be simultaneously "solving" and "not solving" his problem. We could define this paradoxical state as heroism. Whether Eric emerges as an example of the first or the second process is a question to which I have a personally satisfying answer, but since it will have no bearing on the general argument there is no point in imparting it.

Another subject in whom it was difficult to demonstrate ultrastability was Joan, but for somewhat different reasons. Whereas Eric was alert and unbeatable, Joan was slow but imperturbable. Recall that if Q made "late" responses he was immediately warned by a buzz from the computer and then later by E, using the guilt-evoking reproof that too many late responses would render the data impossible to analyse. Under these conditions most subjects seemed to try very hard to keep their responses within the specified interval and became very flustered when they had a "bad run of buzzes". But not Joan. Since her large number of late responses did threaten to distort the results, it was E who was put into a critical state. And he reacted to this primary operation by easing Q's time parameters. To be fair to Joan, she did say that she had trouble distinguishing left from right. Joan's result, like Eric's, was positive but meagre.

The best example of ultrastability was manifested by Steve. He started the day by being "frustrated" and "confused". Table 3, p.128 shows that the slope of his best-fit line was the largest of the seven subjects for whom this was calculated and he ended with the largest tone-contingent divergence on the assessment trials. Since his reinforcement ratio was specified at a figure that was never less than 50%, one might imagine that he would have ended the day on a despondent note. Instead, what do we find? Beaming, he reported that he "knew exactly what was going on"! In the post-test Howells-effect rank-ordering he was second only to Nevil. A "new stability" had indeed been established.

This leads us to the significance of Taylor's concept of "function-functional equivalence classes". We can trace its beginnings to a paper entitled "A Theory of Perceptual Constancy".

A central problem of perception theory is that of constancy. We are faced with the fact that ...patterns of stimulation stand in a many-one relation to perceptions. Effective perception depends on the result of compounding these relations yielding a relation between objects and perceptions which, at least within certain ranges, will be one-one...

It is suggested that constancy can be established by conditioning each element of an 'equivalence class' of states of stimulation to the same group of responses.

Our hypothesis is that the physical invariant underlying the equivalence classes is not an intrinsic property of the stimulation states or of the anatomically determined brain processes set up by them, but is to be found in the set of responses with which these stimulus states have been associated through the individual's commerce with the external world.

(Taylor and Papert, 1956)

If we recall that the solution to the puzzle is: respond to the tone if the colour is saturated; respond to the hue if the colour is unsaturated; then, when O masters the task he will (on most occasions) press the left key when both (a) there is a tone in his left ear, and (b) there is a red light in front of him. If a new constancy is to develop as a result of the conditioning of this singular response to both classes of stimuli, the logic of Taylor's concept is apparent.

3.18 Interpretation

The low tone in the left ear will be organized into the functional equivalence class of "red" and by a symmetrical process, the high tone in the right ear will be organized into the functional equivalence class of "green". The compound afferent inputs are made up of both acoustic and photic stimuli, but when Q is asked to describe the colour he sees his answer, if the constancy does indeed develop, will depend on the formation of a temporary neural structure whose activity mediates the singular response conditioned to both classes of stimulus.

At the end of the day, Steve was receiving intra-session feedback (in terms of overall percentage correct responses) as follows:-

Session No. 17

<u>No. of trials completed</u>	<u>% correct responses</u>
64	93.7
128	87.5
192	89.1
256	92.2
320	90.6
384	90.6
448	85.9
512	85.9

In spite of a 50% positive and negative reinforcement schedule, Steve was misled into thinking that he had mastered the task in terms of veridical perception. It is easy to see how he could make this uncritical assumption. Since the total session of 512 trials was divided as shown into 8 x 64 "feedback blocks", a percentage of 90.6, say, meant that he actually made 6 errors out of 64 trials, but received immediate (acoustic) feedback on only 3 of these trials. Even more important, what Steve was not aware of was the distribution of these errors. The following is culled from the terminal printout on this last session of the day.

[P.T.O.]

3.18 Interpretation

Non-reversed (conditioning trials) (Low tone paired with R,r
High tone " " G,g)

<u>Stimulus</u>	<u>No. of counted presentations</u>	<u>No. of errors (wrong key-press)</u>	<u>No. of too-late or too-early errors</u>
Saturated R	102	1	2
Saturated G	103	0	1
g(0)	14	0	0
g(1)	14	0	0
g(2)	14	0	0
g(3)	13	0	1
g(4)	8	0	0
g(5)	8	0	0
g(6)	8	0	0
g(7)	8	1	0
r(8)	8	0	0
r(9)	8	1	0
r(10)	8	0	0
r(11)	8	0	0
r(12)	14	0	0
r(13)	14	0	0
r(14)	14	0	0
r(15)	14	0	0

Neutral point between g(7) and r(8)
(No "neutral range")

[P.T.O.]

Reversed trials (Low tone paired with G,g
High tone " " R,r)

<u>Stimulus</u>	<u>No. of counted presentations</u>	<u>No. of errors (wrong key-press)</u>	<u>No. of too-late or too-early errors</u>
Saturated R	23	0	1
Saturated G	24	2	0
g(0)	2	1	0
g(1)	2	1	0
g(2)	2	1	0
g(3)	2	1	0
g(4)	8	2	0
g(5)	7	4	1
g(6)	8	7	0
g(7)	8	7	0
r(8)	8	5	0
r(9)	8	3	0
r(10)	8	4	0
r(11)	8	3	0
r(12)	2	0	0
r(13)	1	0	1
r(14)	2	1	0
r(15)	2	2	0

It will be apparent that most of his errors are concentrated in the reversed "assessment trials", i.e. g(4) to r(11). Out of a total of 47 wrong key-presses in 505 counted trials, 35, or 74.5%, fell into this category. The fact that he was blithely unaware of this can mean only one thing: he saw g(4), ..., g(7) as red when they were paired with the low tone in his left ear; and he saw r(8), ..., r(11) as green when they were paired with the high tone in his right ear. "The lights seemed to be coming towards me. I could discern the colours quite easily. I knew exactly what was going on". What other conclusion could we possibly come to? Here, I would contend, we have the closest empirical indication that the final thought experiment of Chapter 2 (wearing a tone-contingent "spectrum-inverting" device) is not as preposterous as it may seem.

Let us turn now to the relation between stimulus, response, reinforcement and perception.

In arriving at his set-theoretical formulation of perception, Taylor sets about deducing its properties.

Perception normally occurs before any action is taken, and this is commonly interpreted as meaning that it is a necessary link in the causal chain between stimulation and response. Thus Michotte writes:

It is a commonplace that...the biological function of perception is to initiate and direct human and animal reactions. It not only enables us to contemplate our environment, but prompts us to action and enables us to adapt our behaviour to the properties of that environment.

The assumption here seems to be that the temporal priority of perception over action in the mature subject is so universal that its logical priority cannot be questioned.

(Taylor, 1962, p.42)

The gist of Taylor's ensuing argument is this. It is true that in the mature subject perception which is the result of previously acquired readiesses to respond does precede action; but it is not true that this was so when the infant and young child were still involved in the business of their acquisition. Here it is the consequences of any action taken which determine whether that response category will become conditioned to the relevant equivalence class. But even in the mature organism we have a multi-stable system in which some sub-systems are continually involved in new adaptations, and in the process of these new acquisitions, perception will be temporally (and temporarily) posterior to response. If an existing subsystem is disrupted and, by the principle of ultrastability moves towards a new equilibrium, we can expect to catch this process "in the act".

Recall the words our subjects actually used:

"I was confused when I didn't get the bell. I need the bell sound to remind me which is the pale orange and which is the pale green."

"The pastel colours just merge into one. I'm working more by sounds than by colours. But then the colours seemed to come back as I made less errors."

"Whenever I crashed badly, [i.e. made a large number of errors] all the colours merged into one another."

"Couldn't see the reds and blues properly without the chimes."

"I found it difficult to distinguish the colours. The squawker usually meant I was uncertain what the colour was."

"When I make less errors I seem to have more time—I work more automatically—I see the colours more distinctly."

"I think that when you stopped reinforcements it produced a change."

"On some occasions when I saw what I thought was a pastel green I pressed the right-hand key and got a 'wrong' signal. Then I realised I had really seen a pastel red."

"I can't see the colours properly since you reduced the reinforcements." After 100% reinforcements:
"I saw them nicely then."

"If I make less errors I seem to be more certain about the colours and vice versa."

"The unsaturated colours are not clear again. They vacillate [sic] when I make errors especially."

It is not necessary to embark on a detailed analysis of these statements to realise that the usual sequence of perception → response → reinforcement has (in these cases, under the particular conditions prevailing) been radically upset. Moreover, the manner in which the subjects made these statements indicated that they themselves realised that they were being "illogical". They hesitated. They laughed in a self-deprecating manner. They were often unable to verbalise their experience at all except to say that they couldn't understand what was happening, or that it was strange or frustrating or peculiar.

There was nothing in the experimental design whereby these data were "looked for". They were spontaneously emitted. After a given session E would merely ask, "Well, what was that like?" If this produced no response, the question was changed to, "Any experiences you'd like to report?" And, finally, "How were you seeing the colours?"

At the time I had no object during these recorded debriefing sessions but to establish the nature and extent of modifications in Q's colour experiences as a function of the experimental conditions.

I consider these data to be of the profoundest significance for our understanding of the nature of perceptual development in general, and for the genesis of colour in particular.

We come next to the role of drive in the disruption of old perceptual stabilities and in the generation of new response-readinesses and hence new perceptions.

Because we are dealing with organisms in whom a change of drive can occur that is not directly contingent on E's manipulations, some of what follows must be speculative. I shall start with ground that I feel most sure on.

Almost without exception, subjects reported differences in the appearance of the unsaturated colours when presented during the experimental and the testing sessions respectively. Now, although it is true that there were saturated colours in the former but not in the latter, I had already determined, in pilot runs prior to the experiment, that these only added to the error variance; in other words, if anything, successive contrast tended to produce a general bleaching effect and could not have been responsible for the tone-contingent differences found between the within-session assessment trials and the pre- and post-testing sessions. Such tone-contingent differences were not reported by subjects as such because, I have argued, they were in fact incorporated into the photic equivalence classes. The following qualitative reports indicate that in addition to the bleaching effect, other differences were noticed:-

After the second experimental session: "I can't discriminate between green and white now, yet I didn't have any trouble at all in the pre-test."

After the post-test: "I have the same trouble about pale green and pale red colours, but now there seem to be yellow colours as well. I saw no yellow colours during [experimental sessions]."

After post-test: "I saw the pinks as pink and the greens as green—they were a good green—no whites. Different from experimental sessions."

At end of day's trials, before post-test. "The green has become more yellowy than green. The other colours are the same but a bit paler." After the post-test: "The colours were clearer and more obvious than when I had to press the keys."

An explanation for the tone-contingent differences that suggests itself most readily (see Fig. 2, p.87a) is that the experimental task involved a quite different and quantitatively greater degree of drive or arousal. In the task itself, we can assume, interoceptive stimuli were compounded with exteroceptive and proprioceptive (finger-pressing) stimuli in such a way that the total afferent input to which responses were being conditioned was different from that prevailing in the testing sessions.

Corroboration of this is to be found in Os' reactions to reinforcements (which of course were not delivered during testing sessions). I have already quoted these when discussing temporal relationships.

Steve made the most touching comment on the role of drive-reduction in this connection:-

"I'm glad whenever I hear the chimes. They're nice. I feel reassured."

But nearly all subjects had similar reactions, even Silke, who was completely au fait with the contingencies of the experiment.

Another important source of drive-change which resulted in disruption of responses and hence of perception was the "error-chain" phenomenon previously mentioned. Suppose O is performing well over a certain run, i.e. no negative reinforcements were being received, and then—squawk!—a new critical state was produced, with consequences which we are now in a position to predict.

"One mistake can set off a train of others. Then my timing goes haywire. I don't seem to discriminate the pale colours so well then."

I have to wait until a sequence of dark [saturated] colours appears."

"Timing is the most important factor. If you lose your rhythm everything goes wrong. Even the colours seem to lose their character."

"The pastel colours come and go. When I had a good run, i.e. few errors, the colours seemed right on time; afterwards they were off time. When they're off time, they come and go. I'm not sure what happens, really."

A much more difficult phenomenon to pin down in connection with drive is the role of Q's self-instructions. For example, Stan, as I have said, spent the first few sessions intent on cracking a non-existing code, which resulted in a very noisy performance. "I spent too much time trying to work out what you were trying to do, hence my errors."

Another very important source of drive-variance but one which was almost hopelessly difficult to monitor was that which gave rise to Q directing a response towards extraneous targets (extraneous, that is, from E's point of view). I have mentioned that the formation of the new constancy involved the incorporation of the tones into their corresponding chromatic equivalence classes so that Q, in these cases, became largely oblivious of the tones, qua tones. But there was nothing to prevent Q from re-directing his attention to the tones, i.e. "listening" to them—in which case there might be a tendency for the equivalence established to be disrupted. This may be an added reason why the post-tests produced such attenuated results. To the extent that he makes covert responses, such as "that was a low tone in my left ear; I wonder whether the next tone will be in my left or my right ear," E's objectives can be subverted.

We can sum up this part of the discussion by reiterating that the "immediacy" of perception must be taken literally. Perception, for Taylor, is identified with readiness for response. If one readiness is interfered with by another, it is no longer a true readiness, i.e. it is no longer immediate. A really stable immediacy is one that cannot be laid down in a few hours, and in the beginning will be easily disruptible. In an experiment of this kind one gets a privileged view of the "atoms" of perception before they form stable "compounds".

We turn now to the relation between verbal and non-verbal reactions to colour. In Howells' case, of course, no non-verbal responses were required of his subjects, and in the attempted replications by my own students, all except Gilbert (1971) followed this procedure. His failure to elicit the Howells-effect was a great disappointment in view of the careful attention to the stimulus and feedback contingencies which programming our on-line computer permitted. One of his speculations was that whereas the response of saying the word "red", for example was the culmination of a multitudinous set of involvements with the kinds of choice-points which Taylor posits as the necessary condition for the genesis of colour perception, the response of pressing a left-hand key rather than a right-hand key had virtually no ancestry of this kind and that this might have been a crucial factor in his own unsuccessful attempt. My own argument, at that time, was that the word "red" would in any case be uttered subvocally and then only would the appropriate key be pressed, so that the conjecture was not a cogent one.

Only when, during my own experiments, the importance of the concept of immediacy was brought home to me, did I revise this hypothesis. I would now argue that since key-pressing as a response to colour involves a disruption of immediacy, we can expect a variety of instabilities to make their appearance. To put this in another way, to the extent that a well-established response-readiness has to wait upon the building up of another, we have a reaction which is mediate rather than immediate. Depending on a variety of circumstances in their own constitution and conditions of rearing, different subjects will learn at different rates to bring about an attenuation of the unwanted "mediate" (if I may coin a noun-form)⁶. For example, Joan, who revealed during the course of her experimental day that she had a slight laterality agnosia, was a risky choice for an experiment in which this type of response played such a prominent part.

I went on to formulate a further hypothesis which was later definitely refuted (by Steve's result). I reasoned that if a subject did learn to reduce or eliminate the unwanted mediate then his response-readiness would be such that saying "red" and pressing the left-hand key would have equal valences: there should be a one-to-one correspondence. Such a subject, I predicted, would react as im-mediate via the one mode as the other. Since in my own experiment Q was not given any instructions about colour (to begin with at any rate) there was no way

of foretelling whether this would occur as a result of the verbal mediate dropping out or, as a result of the non-verbal readiness being organized into the verbal response equivalence class.

Whatever doubts I had on this score, however, there would be one way of ensuring that the problem would not crop up during the vital post-test session. If the conditions of the procedure were such that (a) Q would react to the colours in his own time, and (b) he was asked to respond by saying "red" or "green", and (c) he thereupon pressed the appropriate key, it would not matter whether he had acquired his new constancy as a result of a predominantly verbal or non-verbal response-readiness.

Steve's results, as I said, gave this notion the lie. In his case, I administered both the verbal-cum-key-pressing as well as the verbal-only post-test—which I should now describe in more detail. I had an aluminium cover made which could be placed over both keys on the table in front of the subject. The subject was given explicit instructions to keep his hands on his lap or at his sides, but not on the table. He was told to respond by merely saying "red" or "green" (which responses were monitored by E through the intercom and translated into appropriate key-presses and relayed to the computer's input register).

Table 2, p.118 shows that whereas his tone-contingent hue divergence was nearly three quarters of a J-unit, at a very high level of confidence, on the verbal-only test, this went down to less than a fifth of a J-unit and at no significant level at that. After that experience, I used the verbal-only condition in both pre- and post-testing with all subjects.

The reasons for this discrepancy, which, I am certain, would have applied to most subjects, though in different degrees, are to be sought not only by referring to the previous discussion on mediates, but more pertinently, to the earlier discussion on the role of drive. Steve had, by whatever means, acquired distinctive key-pressing response-readiness to two equivalence classes of stimulation—a red (into which the low tone was incorporated) and a green (into which the high tone was incorporated). But there were other afferents (besides the tones) which were also incorporated into the equivalence classes of the respective photic stimuli, including not only the proprioceptive (finger-pressing) but also the interoceptive afferents arising out of the critical state into which the

system was thrown. When placed in the verbal-cum-key-press post-test situation, elements of these latter afferents served to ensure that the equivalence-classes built up were still reasonably intact; but in the verbal-only situation, these proprioceptive and interoceptive afferents must have largely dropped out, with the result that the photic stimuli were no longer part of this larger equivalence class and so the previous constancy was not manifest.

As a result of failing to take Taylor's axioms literally enough, I succeeded in learning a lesson which no text-book (including Taylor's own) could have taught me. The issue concerning verbal and non-verbal reactions to colour is not a simple one, and I should like to examine it further. We tend to assume that the most immediate reaction to colour is to pronounce the word which describes it, and many anthropological studies have used this assumption in order to assess how different cultures perceive the spectrum. Unless we adopt a strict behavioural viewpoint, however, we could be led astray. Ray (1953) testifies to this. He draws a distinction between "color descriptors" and "color terms". Descriptors refer to certain objects or events to which certain culture-linked responses are directed.

The most significant characteristic of color descriptors—to coin a word—is the fact that they form no system; they are merely a random collection of useful words gathered from diverse sources. As such, there is an amazing tolerance to their careless usage—one can hardly speak of inaccurate usage—and consequently great variation from person to person.

The perception of colors in descriptive terms is an exceedingly complex phenomenon. When I see a brightly-colored sunset my behavioral response, if linguistic, may not involve color at all but, instead, fire, waves, clouds, dusk, autumn, beauty, music, rest. Or a rose: beauty, odor, loveliness, softness, dew. And if color response be involved it is apt to be in terms of descriptors, not color terms. The latter relate to concepts, the former to things.

Perhaps the significance of what I have called color terms proper and the basic color system is now more clear. Perception of color and behavioral response thereto is our problem; not description of color...It is not an easy task to separate proper color terms from words which are merely descriptors, especially when the culture and its language are not too well known.

(Ray, 1953)

If I read Ray correctly, it must mean (if we may perform another quick thought experiment) that we could "design a culture" in which the primary response to a certain (frequently occurring) class of what we call "red" objects (in certain contexts) is to make a downward movement with the left hand, and *mutatis mutandis* for "green" and the right hand. An individual born into such a culture might then describe such colours as being "left" or "right". They are as much "descriptors" as say, "burgundy" or "chartreuse". His response-readiness would be such that in our experiment there would be no "mediate" (as far as the critical unsaturated colours were concerned, at least) and we might find that asking him to do a verbal-only post test (in which he would use his colour descriptors "left" or "right") would not result in a disruption of the established equivalence classes in the way that happened with Steve.

We may now return to Howells. I have said that his basic contentions have been vindicated by the outcome of the present experiment. But I have also said enough in previous sections to show that in certain important ways his design was inadequate, or not described in such a way as to be replicable. One of the first things to do, in the light of the quite small tone-contingent hue-shifts reported in the present study, is to try to establish the size of the shift which he obtained for the two out of his eight subjects whom he tested on the method of adjustment.

Using our J-unit scoring system, this proves to be quite a simple exercise. Howells pooled the results of these two subjects, each of whom were required to make 100 settings while the low tone was sounded and 100 settings while the high tone was sounded. The difference between the pooled means thus obtained, on his arbitrary scale, was 0.78. He does not report the individual or the pooled standard deviation, but he gives us the standard error of the difference between the means, namely 0.19. On the assumption that the two SDs were equal, we can establish that each was equal to $0.19 \times \sqrt{200} = 2.687$. On the assumption of normality the interquartile range = $2.687 \times 1.35 = 3.63$, and the tone-contingent difference expressed in J-units is thus $.78/3.63 = .215$ J-units! There was not one of my conditioned subjects who did not do better than this

on one test or another. Furthermore, if we recall Taylor's (1958) words in describing this part of the experiment, we see immediately that he committed a gaffe. "If this [manipulation] was done to the accompaniment of [the low tone] the light which the subject saw as white was invariably an unsaturated green, etc." (emphasis added). Taylor was misled (ironically, in a paper devoted to an attack on mere test-of-significance types of psychological research) into thinking that Howells' critical ratio of 4.1 (which with 398 DF gives $P = .000049$) was, by itself, a sufficient index of a psychophysically significant divergence. (Howells himself noted, more moderately, but still inaccurately, that "this seems to constitute reasonable proof that the tones actually exerted a coloring influence upon the visual perceptions, independently of any verbal response".)

I did not stumble on this rash overestimation (luckily enough) until several months after I had completed my research into the Howells-effect. It was Taylor's own enthusiastic description that inspired me (and my students) to try to devise a way of uncovering the Howells-effect.

Actually, Howells' two subjects must have manifested a much greater shift than this. His method of adjustment was such that the "interserial adaptation effects" (Hurvich, Jameson and Cohen, 1968) would have all but nullified the tone-contingent differences, since Q had to move from a completely saturated red or green (on alternate trials) to obtain his neutral point, and the duration of exposure was quite uncontrolled. Vogelmann (1971, 1972) and Gilbert (1971) both found that our own method of adjustment gave results which showed far too great an intra-subject variability—and E in these cases had Q move only a small distance away from his approximate neutral setting.

Taylor was of course guided by his axioms: the subjects ought to have shown a substantial shift. And of course he was right. Which is a neat example of the thesis contained in his very paper that the scientist should be guided by an overall theory rather than by piece-meal statistical "evidence".

This leads us to the question of error variance or "noise" in my own data. The overall mean interquartile ranges serve as rough indices of each subject's "noise level". Table 1, p.117, shows that Emily's noise-level was the largest of all subjects (for whom it could be

calculated); while that of Nevil was the lowest. Nevil would be our first choice for a renewed attack on the Howells-effect; Emily our last. So, by Taylor's own criteria, we cannot do without "experimental design", at least in some of its aspects.

I should like to end with a brief discussion of those features of my own design which I would retain, and those which I would replace by others, in future work in this area.

I have already mentioned the necessity for having a whole range of different puzzles whereby Q achieves a new constancy in the process of success rather than failure, on a given task. It is not necessary to detail the nature that these might take: one is limited in this regard (apart from the instrumentation at one's disposal) by one's own imagination

I have not, so far, devoted much space to the use of hue-attenuating and light-occluding goggles, but I believe that a great deal of the success with the first four subjects (Stephen, Stan, Steve and Nevil) was due to their having worn goggles at all times outside the experimental and testing sessions. This conjecture is reinforced by the fact that Nevil, who wore the light-occluding goggles, yielded the best results even though he knew what my aims were and tried hard not to be conditioned.

The use of near-monochrome goggles would seem to be a very convenient way of producing chromatic deprivation effects and thus loosening the "interpenetration" (to use Taylor's term) between the subsystems of colour and spatiality. Since the development of colour constancies is almost entirely due to our experience of colour in the object mode, the wearing of monochrome goggles might have an effect similar to being confined within an environment (as in the first thought experiment presented in Chapter 2) in which colours appear only in the illumination mode. If worn over several weeks, subjects in a distributed-practice experiment should prove to be much more easily conditionable.

The most important amendment to the computer programme (apart from its use to introduce a variety of puzzles) is to call for a continuous analysis of Q's performance in terms of the J-unit differences (or some convenient statistic). This would enable E to select promising subjects within an hour or two and would allow him to maintain a much more delicate control over the contingencies employed. In particular, it

would be important to keep the range between Q's two neutral points non-reinforced when, and only when, this range gets wider and wider as a result of the formation of the new constancies.

Finally, the intermittent-exposure method of adjustment which was developed for the second subject of the gaze-contingent study (see p.192) should be employed as a post-test. Here the exposure and adaptation intervals are under computer control, the only manual task (for E) being to re-set the vernier scale at a small (and randomly) varied distance to either side of Q's previous neutral settings, on alternate trials.

Notes

6. I have adopted the substantive "mediate" to distinguish it from "mediator" as used in quite disparate contexts, e.g. mediation theory (Osgood) and communication theory.

Chapter 4. Empirical Evidence: Conditioning of Gaze-Contingent Hue Responses

4.1 Kohler's Original Study

Ivo Kohler's work with two-colour spectacles stemmed from his collaboration at Innsbruck with Theodor Erismann on the behavioural and perceptual effects of wearing various distorting devices. According to Taylor

Erismann was the first investigator to follow up Stratton's lead, and the first to extend the field of investigation to other transformations of the retinal stimulus... The planning of his earliest experiments was apparently guided by the belief [subsequently modified] that the changes in perception reported by Stratton were closely bound up with the restoration of behavior adequately adapted to the environment, and...it was precisely this [original] belief that was responsible for his work being so fruitful...He insisted that his subjects should not content themselves with gazing at the world...but should go out and engage in the widest possible activities...riding a bicycle, mountain climbing, skiing...[and even wielding a soldering iron].

(Taylor, 1962, p.172)

This emphasis on motor activity and adaptation to the demands of the everyday environment (even if its significance was not tied in with learning theory) could be of great importance in trying to assess the discrepancies between Kohler's (1951) original findings and those of later investigators to be described below. In reporting his own

experiences with blue/yellow spectacles he made frequent references to eye/head relationships, bodily postures, and so on. That he did not provide enough information of this kind (nor, for that matter, of measures of the hue changes perceived) is a pity, but his were, after all, the "ground-breaking" experiments (Hurvich and Jameson, 1960, p.105), and psychology's indebtedness to the Eriksman-Kohler partnership cannot be gainsaid.

Since his own 60-day experiment (Kohler, 1951, p.105f.) is now very widely known, there is no obligation to describe it in the detail that the Howells experiment demanded. I shall devote correspondingly more space to the subsequent comments on his findings and attempts to replicate them by others.

The left half of each frame (in the main experiment) was fitted with a blue filter, and the right half with a yellow filter (transmission characteristics of which were not provided). On removing them during and after the two month period, he reported a "situational after-effect": the left half of the visual field was a very faint yellow, the right half a faint blue.

One may assume that the fovea has acquired a "yellow tendency" as a result of eye position to the left, and a "blue tendency" as a result of eye position to the right. The former acts to reduce sensations of blue, the latter to reduce sensations of yellow...

(Kohler, 1951, p.113)

Kohler's "explanations" of the phenomena are difficult to evaluate as such. He calls them, "situational after-effects" (to be distinguished from after-images), "situationally conditioned disturbances", and "conditioned sensations", in various places. Taylor, who spent a good deal of time at Innsbruck, comments:-

The perceptual changes are divided [by Kohler] into two main classes, which may be called structural and situational respectively. The situational changes are those that depend on the action taken by the subject to correct errors in manipulating objects... Structural changes are those that occur apparently in the absence of behavioural errors or of any opportunity to correct them. These are attributed to some kind of long-term physiological

adaptation brought about by simple exposure to the distorted image.

(Taylor, 1962, p.304-305)

Since the after-effects, in Kohler's case, lasted for as long as a month this is presumably an instance of both kinds of changes, but Kohler is not precise enough on this point for us to be sure. In any case, the logical status of a "conditioned sensation" is problematical, while the mechanisms underlying the neural changes are not explicated. We are left with no clear specification of the necessary and sufficient conditions for the "Kohler-effect" to occur.

Closely linked to the "situational" principle, but rather more elaborately expounded, is the sensory-tonic (organismic) theory of perception put forward by Werner and Wapner. In a paper devoted to the relevance of the Innsbruck studies to the "controversy between sensorial and organismic theories of perception", they comment:

... A theory of perception is needed which recognizes and deals with particular difficulties in interpreting Kohler's findings.

The principal difficulty concerns the fact that under identical retinal stimulation two or more different percepts may emerge, depending on different postural states of the organism...

Sensory-tonic theory has several basic postulates employed in the explanation of perceptual events. The first postulate had its origin in the attempt to solve the so-called "interaction paradox", which pertains to the problem of how alien elements, such as muscular states of the organism on the one side and sensory processes on the other, can interact. In order to solve this problem we propose that stimulation, whether it comes through extero-, proprio-, or interoceptors is sensory-tonic in nature.

A second postulate is that of "functional equivalence". This postulate asserts that diverse stimuli (visual, auditory, etc.) under ideal conditions, will lead to certain identical perceptual end products...

Another feature of sensory-tonic theory is its field-theoretical nature. The theory assumes that in dealing with perception we must consider the relationship between an object (psycho-physical) and organism (psychophysiological),...

Thus, the third postulate is that a perceptual property is an experience which corresponds to a particular relation between organismic state and stimulus. We may re-emphasize that, in this view, perceptual experience does not correspond to a particular relation between organismic state *per se* but to an organismic state related to impinging stimuli...

A fourth postulate of sensory-tonic theory, critical here, refers to the relationship between what we have previously called an unstable relation ($O_x R' s_y$) and a stable relation ($O_y R s_y$). The postulate states that given an unchanging stimulus (s_y) which is in an unstable relation to the existing organismic state (O_x) there is a tendency for the organism to change its state from (O_x) to (O_y) so that a higher degree of stability is obtained between stimulus and organism; that is, ($O_x R' s_y$) changes in the direction of ($O_y R s_y$).

[That] Kohler's work significantly contributes to organismic theory hinges upon his work with color. His finding that color is affected analogously to spatial properties by organismic states broadens the conceptualization involved in sensory-tonic field theory to include a nonspatial property of visual perception... That muscular or kinesthetic happenings, such as the position of the eye, can serve as a frame of reference within which color stimuli are experienced again brings up the "interaction paradox" [which] has to be faced by any perceptual theory.

(Werner and Wapner, 1955)

I have quoted from these authors at length because their theory, *prima facie*, has some remarkable similarities to that of Taylor's. To pursue this in detail is outside my scope, but let us note that the first postulate is congruent with Taylor's notion that all perception involves proprioceptors, interoceptors as well as exteroceptors, i.e. that perception cannot be understood as a mere function of afferent exteroceptive stimulation. The second postulate is incorporated by Taylor's notion of "functional equivalence classes". The third postulate is echoed by Taylor's insistence that "a sense-datum is... the realization of a potential relation between an organism and a

detail of the environment". The fourth postulate looks remarkably like Ashby's notion of "ultrastability" on which Taylor has drawn so heavily.

The question that has to be asked, therefore, is "Do Werner and Wapner give an adequate specification of the organism-environment variables that have to be manipulated in order to elicit the Kohler-effect?" On the basis of the paper from which I have quoted the answer is, No. Their generalizations and postulates may be unimpeachable, but they are far too global to make the kind of predictions (or even postdictions, which abound in Taylor) that will lead to a fruitful interplay between theory and experiment.

We may conclude this section by noting that whatever one's theoretical leanings, the Kohler-effect, if verified, is of profound significance to theories of sensation and perception in general, and to colour theory in particular (Hurvich and Jameson, 1960, p.105; Attneave, 1962, p.646-647).

We now look at three independent studies, all aimed at replicating Kohler's findings.

4.2 Three Attempts to Reproduce the "Kohler-effect"

The first and by far the most detailed report of an attempt to reproduce the gaze-contingent changes in hue perception is that of Celeste McCollough (1965).

She begins by noting that:-

...the novelty [of the Kohler-effect] is the report that the same region of the retina can show alternately the effects of blue-adaptation and of yellow-adaptation, contingent only on the position of the eyes in the head [and that her study was undertaken to obtain]...a more precise specification of the nature and extent of these gaze-contingent color changes.

(McCollough, 1965.)

Her procedure followed Kohler's, except that,

- (a) the colours were placed in front of one eye only, the other being completely occluded,
- (b) the filters used were red and blue-green (of high density)
- (c) extensive colorimetric tests were performed before, during and after the experiment, and
- (d) it is likely that her behaviour differed from Kohler's, while wearing the spectacles.

It is the last point which needs careful scrutiny. In order to obtain his own reactions to McCollough's report (since she failed to obtain the Kohler-effect), I sent a copy of her paper to Dr. Taylor and quote from his reply:-

The first thing to be noted is that McCollough has not understood my interpretation of Kohler's results. She thinks that I accept Kohler's conception of "conditioned sensations", whereas in fact what I suggested was that when the same object was viewed in succession through the blue and yellow filters, the same responses (such as colour naming, selection or rejection for one purpose or another) were conditioned to both photic stimuli, which were thereby organised into an equivalence class, and therefore became identical in consciousness.

Now let's see what McCollough did. She reports that when reading she kept the dividing line between the filters in a fixed position on the page, so that no part of the page was seen through both filters in succession. In any case, if she had [moved the book] this would have had no effect, since the responses of reading are not in any way determined by the colour of the paper. The Financial Times is printed on pink paper and that makes it easier to select from among the available papers, but it makes no difference to the absorption of information from the printed matter. So far as its effect on the development of gaze-contingent colour perception was concerned, the time McCollough spent in reading through the filters was completely wasted.

"In outdoor activity, I kept the boundary near the centre of the field to which she was attending and deliberately moved her eyes in such a way as to observe objects in both coloured fields." That is to say, she specifically avoided the kind of action --inspection of objects through both filters--that I consider to be essential for the development of the gaze-contingent effect. This action requires a rotation of the head about its vertical axis, with compensatory movements of the eyes in the opposite direction. McCollough confined her actions as much as possible to non-compensatory movements of the eyes. Her experiment, therefore, serves to test the conditioned sensation hypothesis, which in any case does not need to be tested because it is unacceptable on logical grounds alone. But it does not test the behavioural theory.

(Taylor, 1971, personal communication.)

He later goes on to say that in Kohler's case the kind of behaviour his theory calls for must have occurred "fortuitously". (A close examination of Kohler's report bears out this assumption to some extent, as I have already indicated.) But what is crucial for Taylor, of course, is not merely inspection of a given object through both filters, but learning to make the same response to this object, irrespective of the mode of regard (and therefore of the difference in photic stimulation). We have no way at all of establishing from Kohler's report that the same response ("colour naming, selection or rejection for some purpose") was in fact conditioned to the two photic stimuli; and when we re-read Taylor's (1962) analysis of this report (p.255-259), it seems that he (Taylor) took for granted that anyone wearing two-colour spectacles over a protracted period would have to undergo the kind of conditioning he postulates. How else could he end by saying, "This calculated result [the after-effect] is confirmed in every detail by the report of the experiment" ?

If it is true that, from Taylor's point of view, McCollough's study was misconceived and therefore doomed to failure, are we absolved from further examination of her report? By no means. McCollough's is a carefully executed experiment, even though we are left in doubt about the behavioural parameters vital to Taylor's theory.

We return then to the other ways in which her procedure deviated from that of Kohler's.

Firstly, her decision to confine herself to monocular viewing was a risky one. She justifies it by saying:

It is unlikely...that conditioning occurs only when both eyes look through coloured spectacles. Where care is taken to prevent conflicting use of the other eye, consistent exposure of either eye surely ought to yield conditioning. Furthermore, a series of binocular experiments by Harrington (1965) also has failed to give evidence of the conditioning of hue-perception.

This is not entirely convincing. If we are dealing with a learning process, the chances of interocular transfer are certainly not nil. Taylor's theory makes no predictions on this score, but behaviour theory apart, the large number of unknowns in interocular

transfer are legion. The question of whether the Kohler-effect is subject to this kind of generalization is a secondary one and will no doubt be tackled by workers in the future. McCollough has perhaps done us a service in alerting us to a potential pitfall. It is true that she found "no gaze-contingent difference with either eye alone or with both eyes together," either in ordinary subjective observation or in formal testing situations. I would still maintain that we do not know enough about interocular transfer to introduce it in this fashion.

Secondly, her use of red and blue-green filters, where Kohler had used yellow and blue, requires some attention. Again, she points to Harrington's study in justification. Harrington's spectacles were constructed of red and blue-green cellophane filters provided by Kohler himself. It is highly unlikely that cellophane filters (unless more than one layer was used) possessed the high density of McCollough's Bausch and Lomb Signal Green and Signal Red.

If filters of too low a transmittance are used there is the danger of a distorting-device becoming a "blocking-device", leading to loss rather than transformation of information.

Finally, the very extensive colorimetric tests that were performed could have contributed to a more rapid extinction of any conditioned responses than would otherwise have been the case. McCollough may not have appreciated the fact that during testing a process diametrically opposite to that which Taylor's theory demands is occurring. To the extent that the same responses (e.g. colour-naming) are made on gaze-left as well as on gaze-right, and are not reinforced, what is almost tantamount to counter-conditioning is taking place. When one is dealing with quite small perceptual shifts the danger of rapid and complete extinction is all the greater.

McCollough deals at length with Kohler's own findings, providing an explanation in terms of simultaneous contrast induced by long-term adaptation of the periphery of the retina, rather than a "situational" or conditioned-response interpretation. I do not propose to deal with this question, but there is one comment on Kohler's results which calls for a strong rejoinder. Towards the end of her paper she comes to the conclusion that:

...the magnitude of the gaze-contingent effect is much smaller than most persons seem to have assumed from their reading of Kohler's published reports. It is seen as a slight variation in the toning of a very desaturated test-field.

This conveys the suggestion that although Kohler could describe the nature of the after-effect, its size was so small as to elude measurement. McCollough had the benefit of the most sophisticated psychophysical techniques at her disposal, and it is unfair to imply, as I think she does, that Kohler's gaze-contingent shift might itself have been so small as to elude detection by its means. The matter is a simple psychophysical one. Kohler's after-effect was not "just-noticeable": it was at least "just-perceptible". In other words, if an adequate metric were used it could have been measured. No amount of discussion about the "slightness" of the effect can gainsay the fact that Kohler said he saw the right field as tinted with a "bluish shade" and the left field as tinted with a "warm yellow" shade (and similar statements). It is the job of the colour-scientist to translate these self-reports into commonly accepted units of, say, chromaticness (if he can), not to minimise them with words of his own.

We turn now to the report (also negative) already alluded to by McCollough, namely that of Harrington (1965). In his study three observers wore "split-field glasses", using red and blue-green filters obtained from Kohler himself, for 38, 103 and 146 days respectively.

Taylor refused my invitation to comment on Harrington's paper "because it says nothing of what the subjects actually did during the experiment". This is surely disingenuous. At the very least we need a specification of what a man must do so as not to achieve the effect over a period of nearly five months!

Finally, the only successful replication reported (up to October 1971) is that of Leppmann and Wieland (1966). By contrast with Harrington's marathons, this was a quick sprint; and compared to both McCollough's and Harrington's failures, it was an unequivocal success.

Leppmann himself was the subject and the whole experiment lasted 11 days, with the following two days devoted to informal observations. The filters are described as violet-blue and chartreuse, with optical densities of 0.8 and 0.2 respectively.

This disparity in densities caused the subject a good deal of "annoyance and frustration" and he reported having to "constantly fight the intrusion of the blue field". He apparently realised the importance of not relying on the yellow (right) field only and succeeded in combating the "head-left-eyes-right" posture that he was tending to develop.

He retired on the night of the eleventh day wearing a blindfold all night. On the next morning he commented as follows:

...I am seated about six feet from a...screen. I now remove my blindfold. On the left-hand side I see a very bright yellow tinted field, almost as bright as the after-image of the first day, but with a much sharper outline. On the right-hand side, separated by a relatively sharp dividing line, there is a highly desaturated light blue, almost gray, field. By moving my eyes (but not my head), I can eliminate either of the two fields and see only the bright yellow one or the faint blue one, and the dividing line does not move at all. It is indeed, as Kohler has described it, 'as though I were looking into my own afterimage.' Moving my body by turning the chair, the entire illusion disappears, and it requires refocusing before it reappears. Looking at the screen from a 45° angle, the left field of vision becomes brighter, but I detect no changes in the right. At noon the color aspect of the aftereffect has almost totally disappeared, but the intensity of light on the left-hand side remains. Everything looks brighter in an 'eyes left' position, and duller in an 'eyes right' position, exactly the opposite of what had been true during the time I wore the glasses. This difference could be observed for at least another 24 hours.

There are many questions that could be asked about the reasons for this easy victory when others had toiled in vain for so long.

Is there after all something about the yellow/blue combination which produces results that the red/blue-green combination is unable to emulate? Were Leppmann's behaviours so significantly different from those of Harrington's subjects and from McCollough's?

If Leppmann, on his own declaration, spent more time looking through the yellow filter, why was the gaze-left after-effect described as "very bright yellow" and the gaze-right as "highly desaturated light blue, almost gray"? Would McCollough have written Kohler off so cavalierly had she known of Leppmann's results?

My own investigations to be described later are certainly not going to provide answers to all these questions. I ask them because they are puzzles relevant to the present study. I shall content myself here with saying that after reviewing these three studies, the filter-combination that I was determined to avoid, in order to put Taylor's hypotheses to the test, were yellow and blue.

Notes

1. Another reason for not minimising the original Kohler-effect is that Kohler (1964) reports it as having lasted for "at least a month".

4.3 The Kohler-effect and the Behavioural Hypothesis

To paraphrase Taylor's comments, quoted in the previous section, the behavioural theory of perception generates the hypothesis that the Kohler-effect will be obtained if

- (a) the same response is made to a given object viewed in succession through each of the filters, and
- (b) this response becomes conditioned to each (transformed) photic stimulus.

Condition (a) is necessary, but not sufficient. It is essential for us to be clear on this point before considering the implications of condition (b).

Consider Fig. 9 in which the head and (cyclopean) eye are rotated about their respective axes in such a way that a given object is viewed firstly through filter F_1 and then through the complementary filter, F_2 . The first mode of regard we could call head-left-eye-right (HLER) and the second, head-right-eye-left (HREL). Suppose the object in question is a tomato. If $\underline{Q}$ makes a response such as saying, "That's a tomato" in both the HLER(F_1) and the HREL(F_2) conditions, this by itself would not ensure the evocation of the Kohler-effect, even though the response in question is both singular and correct. There are of course many instances in daily life when a subject would make this type of response under these conditions, and it is not necessary

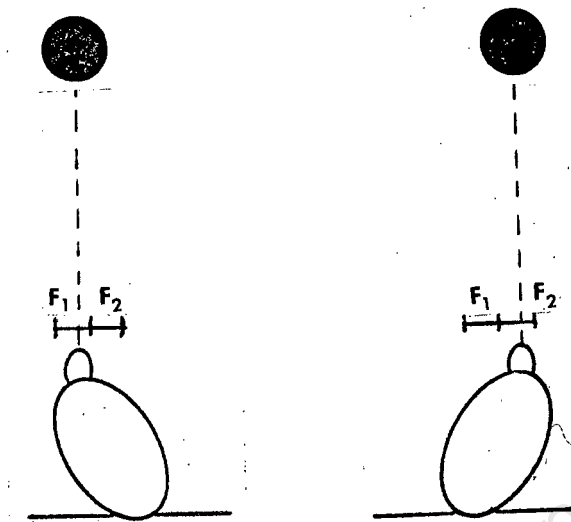


Fig. 9. Bi-coloured spectacles: two modes of regard.

to list them. Now consider the case when the object in question is an orange. If he learns to identify this fruit in both the $HLE(F_1)$ and $HREL(F_2)$ conditions, condition (a) is certainly satisfied, but there is a problem about condition (b).

To go back to the first instance; to the extent that Q learns not merely to identify the object (under both conditions) as a tomato, but as a green tomato (other modes of perception and cognition being excluded), he is on the way to learning the kinds of responses that Taylor considers both necessary and sufficient for the elicitation of the Kohler-effect. How would he learn that a given tomato is green, and not red? In much the same way, so goes the behavioural theory, that the child initially acquires the stabilities of colour perception. He might reach for it, and by palpation, or failing that, by taste, he would receive positive or negative feedback in conjunction with the actual retinal stimulation. If he has a companion whose colour-vision has not been subjected to distortion, the feedback could simply be a verbal one. If, in a variety of situations such as these, he eventually learns to make rapid and correct discriminations and colour-responses under both conditions of regard, he is learning a new constancy, or as Taylor puts it, to the extent that the (proximal) photic stimuli are

organised into a single functional equivalence class, they become "identical in consciousness". The result is that, regardless of the difference in wave-composition of the two retinal inputs, the object comes to be seen as having the same colour. When the filters are removed, the same readiness for response is there (initially, at any rate) and the functional equivalence classes that were previously established continue to operate, so that HLER now results in perception having the chromatic characteristics of F_2 , and HREL of F_1 .

Now, in the other case, O could learn to say, "That's an orange", in both gaze conditions, but unless we question him we could not be sure of its significance. To the extent that he initially confuses oranges with grapefruit (say) and learns to make correct discriminations on the basis of texture, size, shape, etc. and ignores the chromatic cues, he will not acquire any new colour constancy. (And there is nothing to stop him from learning to make discriminations which are not chromatically-cued even with tomatoes, we should note; it would simply be more difficult.)

The reason for this rather laboured discussion is to make it quite clear that by asking a subject to wear two-colour spectacles, and allowing him to go about his normal routines, no matter for how long, we cannot hope to subject the behavioural hypothesis to a really stringent test.

But we can go further. Suppose that someone (such as Harrington's third subject) does wear such spectacles for a very protracted period and does not manifest the Kohler effect. Taylor's theory allows us to deduce that his behaviour must have been such that he relied on the host of non-chromatic cues available in making whatever adjustments were necessary, implying a kind of "colour agnosticism" on his part.² (We might liken him to those of von Senden's ex-cataract patients who would not learn to use retinal cues and therefore remained functionally blind even though, physiologically, they could "see".)

To be still more specific, we may predict that if the wearing of two-colour spectacles does not disrupt the ultrastability of that subsystem concerned with adjustment to the chromatic elements of the material environment, then the Kohler-effect will not occur.

Having reached this conclusion, it occurred to me that of the three reports described in the previous section, only in Leppmann's case was there a specific mention of initial disruption of behaviour:-

First Day

The glasses are a constant source of annoyance and frustration. I feel unsure of myself and there appears to be some effect on my motor co-ordination as I walk down the hall of the building. I have trouble looking at people on my left who speak to me... Walking straight ahead, I keep thinking I am bumping into people, but when I turn my head and look through the yellow portion, I find that they are three feet away. By evening, positioning of my head to obtain maximum use of yellow portion during gross motor movements has become almost automatic, although the span with which I am able to maintain this position is very short and I am constantly fighting the intrusion of the blue field.

Second Day

I am beginning to notice increasing fatigue resulting from the conscious effort to keep within the yellow field. After two hours of reading, or rather scanning, I experience some dizziness. It seems to result from moving my head, i.e. from moving the glasses in relation to my eyes, because when I actually read without moving my head, the color contrast is much less sharp and no dizziness results.

(Leppmann and Wieland, 1966)

That Leppmann subsequently experienced complete but very temporary restorations of ultrastability, is evident from the following extract:-

Fourth Day

I have been sitting in an auditorium listening to a lecture without taking notes. Suddenly I realise that I have been unaware of the glasses for the last half hour. Everything looks perfectly normal. Something has caused me to turn my head, and now the contrast of the two color fields is as sharp as ever, and there is a dividing line in my field of vision.

Ninth Day

I am reading a book which has completely captured my interest and requires absolute concentration. Suddenly I become aware of the same phenomenon as was described on the fourth day. I have been unaware of the glasses, but a noise at the window caused me to turn my head, and I am once more struggling to keep my eyes out of the blue field.

In the absence of further evidence, we can only speculate as to why there is mention, in his case only, of initial disruption and subsequent partial restoration of ultrastability. It may not be irrelevant to note here that the wearing of filters which allow only the long-wave portion of the spectrum to be transmitted on one side and only the short-wave portion to be transmitted on the other may have contributed to what Kohler (1962) and Hajos (1962) have referred to as the "colour stereo effect", a phenomenon in which objects appear to be located at different depths, according to the wave-composition of the light they reflect owing to the (natural) chromatic aberration of the eye. There are considerable individual differences in this respect (due no doubt to differences in lens structure and shape) and in Leppmann's case the phenomenon may have been operating quite strongly.

(The "colour stereo effect" implies that the subject can make chromatic discriminations that are not mediated by the photo-receptors, but this does not affect the logical soundness of the behavioural hypothesis in any way.)

We are now ready to examine the range of options open to the experimenter who wishes to subject Taylor's Kohler-effect hypothesis to an empirical probe.

Notes

2. The concept of "colour agnosticism" is referred to again on p.221 and p.230.

4.4 Producing the Kohler-effect: Experimental Possibilities

The problem we have to tackle now is the purely practical one of how best to train a subject to make the same response to a given chromatically discriminable stimulus whether it is viewed through a filter on gaze-left or another (preferably complementary) filter on gaze-right.

There is no intrinsic reason why Q should wear spectacles, nor why he should have to move his eyes relative to his head. An immediate utility results if the task we impose is such that in order to inspect the stimuli presented, Q has to move his head (to left and to right) with the eyes in the approximate straight-ahead position in each case. The utility results from the fact that it is much simpler, from the point of view of the instrumentation required, to monitor head-movements than to monitor eye-movements.

The Howells study already reported illustrated that the use of an on-line computer in gauging response-readiness with respect to chromatic stimulation is virtually mandatory. This in turn means that the colours are to be presented in the illuminant or aperture mode^{2a}, as in that study.

Let us start with Q seated in such a way that he can see a randomly disposed array of chromatically discriminable lights through the first filter (F_1) on gaze-left, and another array of the same set through the complementary (F_2) on gaze-right; but cannot see them in any other way. Using any method he likes, his task is to identify each stimulus-light correctly no matter through which filter it is viewed.

By "identify" I do not necessarily mean give it the correct colour name; there are many possibilities open to E here. For example, suppose only one of the lights appears on his right at a time. His task is to choose the light from the set on his left which he thinks will be an exact colour-match of the light on his right.

For such an arrangement we need a convenient method whereby Q can make his choice. If we are working with 10 lights we can dispose them so that they are "symbolically accessible". One way would be to situate each light in one square of an 8×8 "chessboard" marked, say, A to H along the "ordinate" and 1 to 8 along the "abscissa". Q indicates his selection of a "match" by punching two characters in a keyboard containing these 16 symbols in front of him; whereupon the light singled out immediately disappears from its position on the left and is now seen (through F_2 of course) next to the original light on the right. Q is now readily able to judge whether his choice of a match was veridically correct; and we can arrange for the delivery of a positive feedback signal to reinforce his judgement if we wish.

If he is correct, a new trial automatically commences after a suitable interval (the duration of which is specifiable by E, say 2 seconds). Now Q sees a single light (randomly selected from the set of 10) through F_1 on his left, and the full set in a random "chessboard" arrangement through F_2 on his right.

If he is incorrect, Q might be given the option of inspecting the mismatch pair for as long as he wishes (the time spent in doing this counting against him, of course); after which he presses a key which leaves the single light where it was on his right, but serves to transfer his mis-selected light back to the array on the left; where it now appears with the other 9 lights in a differently shuffled display. He now indicates his second choice for that trial.

Q's overall task, of course, is to make correct matches (with the filters in position, as rapidly as he would had there been no filters (or neutral-density filters) on either side.

Alternately, suppose that on a given trial Q sees only one of the ten lights on gaze-left and only one on gaze-right. Let these lights be arbitrarily numbered by E, 1 to 10. Now, if Q has 10 numbered response-keys on his left and a similar set on his right, he could inspect the two lights for as long and as often as he wished and "label" each stimulus-pair by responding with "5-7", or "9-4", or whatever. If he is correct, he immediately receives a positive feedback signal and the next trial commences. If not, he gets a negative feedback signal and the same two lights are "held" until he correctly identifies them both.

The first suggestion is probably closer to a naturalistic setting than the second, but it entails some difficulties in instrumentation which in our own laboratory would have taken longer to overcome than I had patience for. The second was easier to set up but it looked as though it would be rough going for Q.

Notes

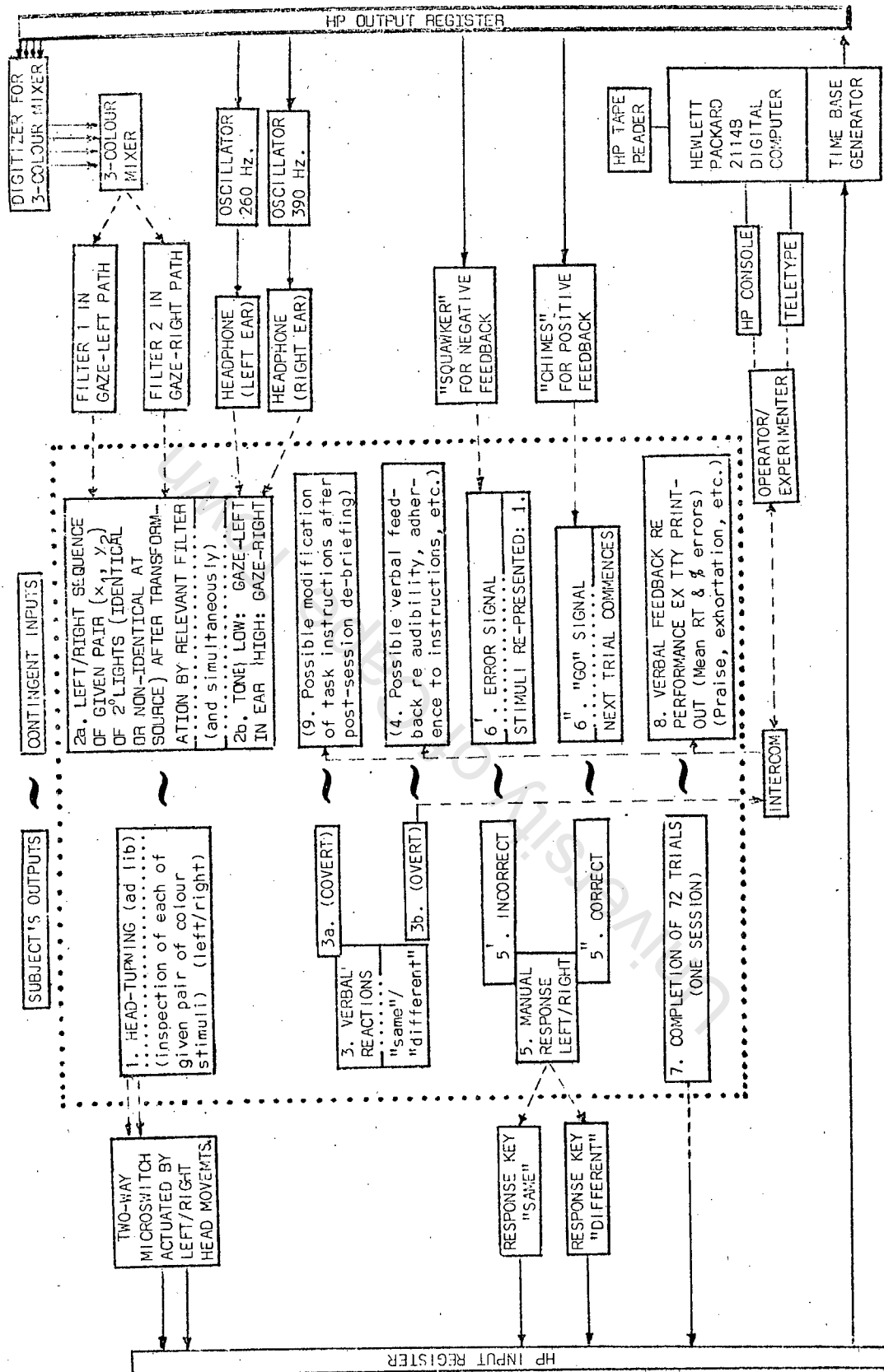
- 2a. Under normal circumstances the illuminant mode is regarded as an object mode, whereas the aperture mode is a nonobject mode. Under the present conditions, however, at low levels of luminance in a dark room, with small (foveal) angles of subtense, the colour-mixers used produced stimuli of a nonobject mode of appearance. The terms aperture mode, film mode and illuminant mode are virtually interchangeable in the context of the present experiments.

4.5 The Present Design

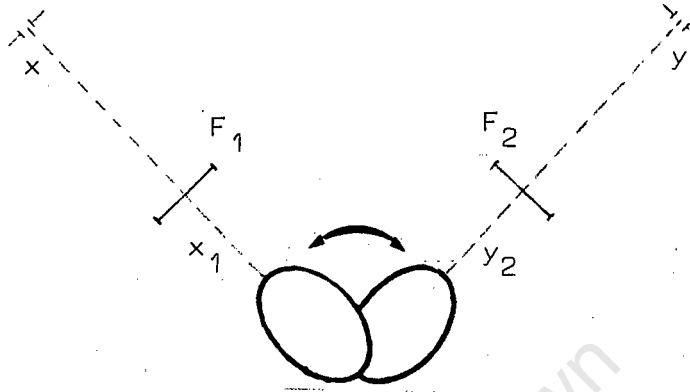
In the experiments to be reported, I decided to make things easier for everyone, and the whole system is depicted in Fig. 10 with the viewing arrangement outlined in Fig. 11. A three-colour mixer (similar in principle to the two-colour mixer used in the Howells experiment) was hooked up to the computer via a digitizer. (see Appendix 1). The arrangement was such that E could select (via suitably prepared software) up to 24 different colours for any given 3-filter combination. I chose to use a basic 9-colour subset.

The computer was programmed in such a way that on monitoring Q's head-movements, it would present the first member of a pair of colours on gaze-left, and the second on gaze-right. This, coupled with the viewing system used, ensured that Q could see the stimuli in no other way.

Referring to Fig. 11 we can describe the arrangement in a more concrete way. (Instead of using the customary lambda symbols for stimuli of different wave-composition, I have used x and y to make the typescript easier to prepare). On a given trial the unseen colour-pair was x and y, seen respectively as x_1 on gaze-left (through F_1 , via the left mirror) and as y_2 on gaze-right (through F_2 , via the right-hand mirror). Q's task was to inspect the transformed stimuli, x_1 and y_2 , (as long and as often as he liked) and to judge whether the unseen source-lights, x and y, were chromatically identical or not.



SCHEMATIZED COMPUTER-CONTROLLED SYSTEM DESIGNED TO PRODUCE GAZE-CONTINGENT SHIFTS IN COLOUR PERCEPTION
Sequence of subject-initiated events are shown in numerical order



CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: BASIC VIEWING ARRANGEMENT

On a given trial, two source-lights, x and y , are presented.

The first light can be seen only on gaze-left and takes on the appearance of x_1 after being transformed by the filter F_1 .

The second light can be seen only on gaze-right and takes on the appearance of y_2 after being transformed by the filter F_2 .

O 's task is to inspect x_1 and y_2 for as long and as often as he wishes, and to judge, using any method he chooses to adopt, whether the source-lights, x and y , are identical or non-identical.

(Simultaneous with presentation of the colour-stimuli, a low tone was sounded in his left ear on gaze-left and a high tone sounded in his right ear on gaze-right. The primary motive for this was to produce an extrinsic re-afferentation contingent on head-turning so as to counter any extinction-tendency when Q was outside the laboratory situation. For this purpose Q wore a pair of stereo headphones which—via a gooseneck coupling—actuated a microswitch which allowed the computer to monitor head-movements and present the stimuli.)

Q's method of communicating his judgement to the computer was simply to press one of two response-keys in front of him, that on the left to indicate "same" and on the right to indicate "different". If he made a correct response he immediately received a positive feedback signal ("chimes") and the next pair of colours was presented. If he made an incorrect response, he received a negative-feedback signal ("squawk") and the next pair of colours was withheld until he made the correct response. Obviously, the correct response simply involved pressing the other key, but the arrangement allowed him to re-inspect x_1 and y_2 and "figure out" (in any way he liked) why he was "wrong".

Our requirement is that Q should learn to execute this task as accurately and as rapidly as he could under the same conditions except for the removal of F_1 and F_2 or their replacement by neutral density filters.

Before outlining the procedure, it is necessary to pause for a moment and consider the assumptions one makes when replacing a labelling or categorising system (such as the second of the two suggestions originally put forward) with a simple "same/different" system. The supposition is that in the latter task Q will learn some private coding system based on his direct experience of x and y when a pre-test is performed without selective transformation to x_1 and y_2 respectively. If the pre-experimental tests involve a few hundred trials Q will remember some, if not all, of the original nine colours and perhaps even label them, A to I, say. In the experimental situation he might then go through the following formula: " x_1 must be an F; y_2 looks as though it could be an A; therefore 'different'".

To the extent that something like this does not happen, Taylor's hypothesis³ is not being fairly tested. For example, Q might proceed without reference to the original A to I source-colours and simply learn his task by rote, as one would a set of nonsense syllable pairs. For example, "x₁ is P (giving a colour-name to its transformed appearance); y₂ is Q; from past experience with the computer P "goes with" Q; therefore say "same". In such a case the assumption is largely invalidated and E's objective is foiled.

(I must own to a certain amount of hindsight in issuing this caveat—as will become evident when the results are interpreted. But my uneasiness on this score definitely occurred before the experiment started. What I could not have done, unless prodded, was to specify my assumptions precisely and show exactly how they could be subverted by Q. However, even had I spelled it all out as I have done above I would still have proceeded as I did, one reason being that the task, although simplified in comparison to the more rigorous tagging system, was still very difficult. My own performance was such that I simply would not have qualified as a suitable subject! I do not regret having used the "same/different" approach to begin with, but it is important, from now on, to bear in mind the premises on which it is based.)

Notes

3. As in the case of the tone-contingent study (chapter 3), it is no simple matter to formulate a crisp statement of the actual experimental hypothesis since everything depends on the "behavioral adaptation" achieved by Q. It is easier, however, to lay down what is at stake in trying to produce the Kohler-effect than the Howells-effect, and I have essayed to do just this for the former on p. 198-199 and p. 204-205.

4.6 Subjects

Since it was decided not to use a massed practice arrangement (and also because funds were limited) only two subjects took part in the Kohler-effect study.

The first, Paula, was an undergraduate psychology student; the second, Kathryn, was an undergraduate majoring in English and had not done any psychology. Both subjects were paid at the rate of R1.00 per hour (inclusive of intervals and refreshment breaks), and both were kept as ignorant as possible of the nature and purpose of the experiment.

Appendix 11 contains "diaries" which summarise the sequence of activities for each of them.

Since there were differences in the procedure adopted with each, I shall detail them separately before presenting their results.

Paula was my first subject, and in her case I had no clear idea of the probable course of events. In particular, I was uncertain as to whether she could learn the matching task at all, let alone to the criterion determined by her own "no-filter" performance.

To be brief, the plan I adopted with her was,

- (a) to subject her to the "no-filter" pre-test,
- (b) to allow her the opportunity of learning the experimental task, and
- (c) to test her after she had reached the criterion (determined by both speed and accuracy) using the same procedure.

Although I was concerned with quantification of results, my main concern with her was, Would she cope with the task at all, and if she did, would she see the colours differently, depending on direction of gaze?

(I will anticipate by saying here that she did cope with the task, and that she did see the colours differently, but that after this she gathered (from my involuntary reactions, presumably) what results I was hoping for and from the 12th day we both were not quite sure of what effect this was having on the results. More on this score later.)

In Kathryn's case, I was ready to ask more searching questions and obtain, if possible, more precise quantification of results, but I was determined that a repetition of the "laboratory atmosphere" or "experimenter effect" (if such it was) should not recur. I therefore did not allow her to see the unfiltered source-colours at all. In her case too, I instituted an extensive control phase in which she was made to perform various bogus or irrelevant tasks which obliged her to look at the colours but not "solve the puzzle", or even know what the puzzle was. Except for certain other experimental details⁴, the course of her training and testing was much the same as for Paula.

Notes

4. A "detail" which does merit some mention here was the presence, in Paula's case, but not in Kathryn's, of a 1° white "pilot light" situated about 2° below the aperture of the three-colour mixer (see p.212).

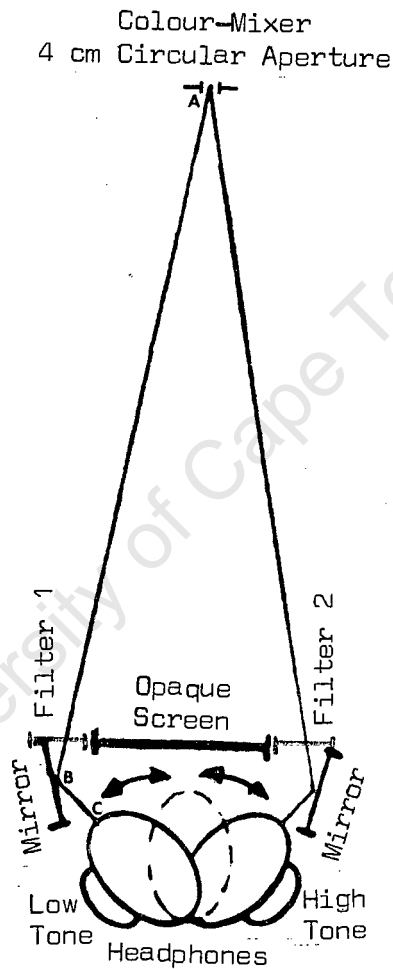
4.7 Procedure

With my first subject, Paula, we began, as I have said, with certain pre-tests. Details of these will be found in Appendix 12. (I might mention here that the conditions under which these tests were performed were changed from time to time in order to obtain more intra-subject consistency, and therefore if it should seem that I have chronicled them too minutely, I hope that the need for this is clear.)

The first test (Data Sheet 1) was carried out in order to ensure that there was no laterality bias in the viewing system (see Fig. 12).

It is clear from this diagram that the viewing angles were oblique relative to the front of the colour-mixer, whereas in the Howells experiment all observations were made perpendicular to the mixer. In testing the two-colour mixer, I noticed that there was a slight discrepancy between my own neutral settings on gaze-left and gaze-right, respectively. What seemed a good grey via the left path had a slight pink tinge via the right path. I decided,

- (a) to reduce the test-field from a 3° square to a 2° circle, and
- (b) to instal two additional lamps in the mixer-box itself which, covered with appropriate filters, "killed" the unwanted angle-contingent discrepancy in chromaticity.



Vertical goose-neck shaft attached to frame of headphones actuates microswitches which, via computer monitoring, results in simultaneous presentation of relevant visual and auditory stimuli contingent on left/right movements of head about its vertical axis.

Viewing Distance ($AB + BC$) = 135 cm

Filters removed when testing for after-effect.

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ACTUAL VIEWING SYSTEM

At least it did so for me, and I wanted to check whether Paula would provide confirmation. I performed a brief and simple open-ended response test using pre-set single stimuli via the colour-mixer's vernier dial. Simple inspection of the results on Data Sheet 1 reassured me (then) that there was little, if any, laterality bias in the viewing system for the two-colour mixer.

In the case of the three-colour mixer neither I nor two other observers could detect by simple comparison of chromatic colours that any bias was present and I did not test Paula's performance in this regard. (Her criterion-establishing pre-test would serve this function in any case, I argued.)

The next test was performed to ensure that the viewing filters were "good" complementaries of the hues produced by the mixer, and to relate the characteristics of the mixer (as quantified in the arbitrary units of the vernier scale) to the characteristics of these viewing filters. The results on Data Sheet 2, Appendix 12, established that, with the red filter in the gaze-left path and the blue-green filter in the gaze-right path, Paula's neutral settings were 65.9 and 33.1 respectively. (Transmission characteristics of the filters used for Paula and for Kathryn are to be found in Appendix 3). (Maximum Red Saturation on Colour Mixer = 0; Maximum Blue-Green = 100)

We were now ready to perform the comparison-tests which would establish her best performance with respect to both speed and accuracy.

The programme for the experiment proper was loaded, but the viewing filters were removed. I was addressed as follows:-

You are to seat yourself at this table and wear these headphones. [E tests tones] When we begin the experiment you are to turn your head to the left, look at the small circular light, then turn your head to the right where you will also see a light. Decide whether the two lights are the same in colour, or different. (You may re-inspect each colour for as long and as often as you wish) When you have made your decision, you will say "same" and momentarily press the key on your left; or you will say "different" and press the key on your right, depending on your judgement. There will be 72 of these colour-combinations per session. After each response, you will be informed via one of two

feedback signals [E illustrates chimes and squawker] whether your response was correct or not. When you make a correct response, the next pair of colours will immediately be available for your inspection, but in the event of an error, the computer will continue to present the same pair until you press the other key. You may use this opportunity to check that your judgement was in fact wrong and in what way. After each session you will be told what your percentage correct responses were and also your mean reaction time. Any questions?

The results of four such sessions are summarised in Data Sheet 2A, Appendix 12, from which her best performance (that on session 3) was taken to be her "target" or criterion, which was 1 error (98.6% correct responses) and a mean reaction time (for her first response on a given trial) of 2.7 seconds. The product of number of errors and mean RT gave a figure which conveniently incorporated both scores, and it is this function which was used as the overall criterion.

(In retrospect, I can say that it was a blunder not to have administered this latter test without feedback before establishing her best performance with feedback. I should also mention, though, that the programme in its state of development at that time, was such that I could not but obtain feedback even had the acoustic signals been switched off. The reason is simple: presentation by the computer of a new stimulus pair meant that her response was right; presentation of the same stimulus pair almost invariably meant her response was wrong.)

We were now ready to begin the training sessions proper, and Q was accordingly given the following instructions:-

I shall now replace the filters; the red one on your left, and the green one on your right. You will therefore be viewing each of a given stimulus-pair only through the red and green filters respectively, and you will not be able to see the colours as they really are. Nevertheless, I want you to try to judge, on each trial, whether the two colours are objectively the same, or objectively different, no matter how they appear. You will again signal your judgements by saying "same" and "different" and pressing the appropriate key, and the computer will inform you as before of the

correctness or otherwise of your judgements. Your overall task, which might take you several sessions, is to achieve a score of 98.6% correct responses (which is equivalent to not more than one error per session) and a mean reaction time of not less than 2.7 seconds. I shall be drawing a graph of the product of errors and reaction time, so your target is 2.7. Do not be discouraged if you find the task very difficult to begin with. You will again be wearing these headphones [E tests tones again]. Any questions?

Over a nett working period of 2.76 hours she therefore completed 22 sessions of training. A specimen TTY printout is presented in Appendix 13. From these and subsequent printouts I culled the data presented in Appendix 14. (What has been omitted in these data sheets are the individual reaction times and standard deviations for each of the nine "match pairs" and for the pooled "mismatch pairs".)

The first evidence of the Kohler-effect was obtained at the end of the third day, after she had completed 5.74 hours of training nett. The relevant analyses of all testing sessions are to be found in Appendix 15.

What I am leading up to in this section is the event on the 12th day, after completing 9.06 hours of training, of a spontaneous comment that "certain of the colours looked pinker on the right-hand side than on the left-hand side". This was made after the modified qualitative comparison test (Data Sheet 4A, Appendix 12) was administered, in which no feedback was delivered or could be inferred. This was confirmed on the following day when she was specifically asked to make judgements concerning the laterality differences in the pairs of colours presented.

The next modification concerned the randomizations of the pairs of colours presented during the experimental sessions. Until the 8th day we had been using 10 different randomizations in haphazard order (to prevent O's memorizing of critical sequences). Her performances until then were at or near the criterion and it seemed necessary to make the task more difficult. I therefore prepared 5 other randomizations in which all the easy "mismatched" discriminations were eliminated, and training was continued with these from the 13th day

until the end of her training on the 20th day.

At the same time as the introduction of the "difficult" randomizations, O was instructed to alternate the starting point of her viewing in order to try to counteract a response bias which had apparently developed. (Her method of dealing with the task had been to look at the first of the pair of colours, gaze-left, and decide what the appearance of the second one would have to be in order to constitute a match. Having made the decision, she would turn her head to the right and make her response in terms of whether or not the prediction was verified.)

The final modification in procedure (for Paula) was introduced after she had completed all training sessions, on the 20th day.

Since there were doubts whether responses of "same" and "different" was a valid method of testing Taylor's hypothesis, I thought it might be worthwhile to introduce a "tagging" technique of the kind previously discussed. A special punched tape was prepared which allowed E to train O to give each of the nine stimulus colours, seen through each filter, an arbitrary numerical label. 180 such practice pairings were presented during which O's role was relatively passive in that she merely indicated when she had completed her scrutiny of each pair. After this she was asked to perform the previous task, not by indicating "same" or "different", but by calling out two numbers for every trial. E monitored these responses and controlled keys which gave O the appropriate feedback. The results of these tests are recorded in Data Sheet 4C, Appendix 12.

We turn now to a general description of the procedures used with the second subject, Kathryn.

As previously intimated, the first set of tasks she was asked to carry out constituted a "control phase". The programme was unchanged but of course E specified "no feedback". O was instructed as follows:

Your first task is to reproduce certain time-intervals as accurately as possible. I shall give you a "time", say of 4 seconds, and you are to spend as close as possible to that time looking at each colour to the left and to the right. You will wear these headphones and a tone will sound in each ear simultaneously with your viewing of the colours. This is to help you in your judgements. As soon as you have spent 4 seconds (say) looking at each of the colours, press both of these keys simultaneously and a fresh pair of colours will be presented. Again try to view the colours for exactly 4 seconds each (or whatever time I shall specify before the session). There will be 72 such trials per session, after which you will be told how accurately you performed.

The times O was asked to reproduce ranged from 1.5 seconds to 4 seconds, and a total of 1.8 hours nett were spent in this fashion. On the third day she was told that her task was now quite different. She was to look quite intently at each colour and say aloud what her "personal emotional and aesthetic reactions" to the particular colour were. She was told that her responses were being recorded and would be analysed later. In subsequent sessions, she was asked to perform such tasks as,

- (a) Describe the colours you see as though you were trying to convey their appearances to someone with whom you had grown up, say your twin brother or sister.
- (b) Describe the colours as you would if you were writing a novel for an intelligent readership.
- (c) Describe the colours in order to convey to a totally blind person what the experiences are like.
- (d) Using four basic hues, red, yellow, green and blue, assign numbers to each colour which indicates how much of each hue it contains, the proviso being that in each case the numbers must add up to 10. For example, you might decide that a colour could be described as red 6, yellow 3, green 1, and blue 0.

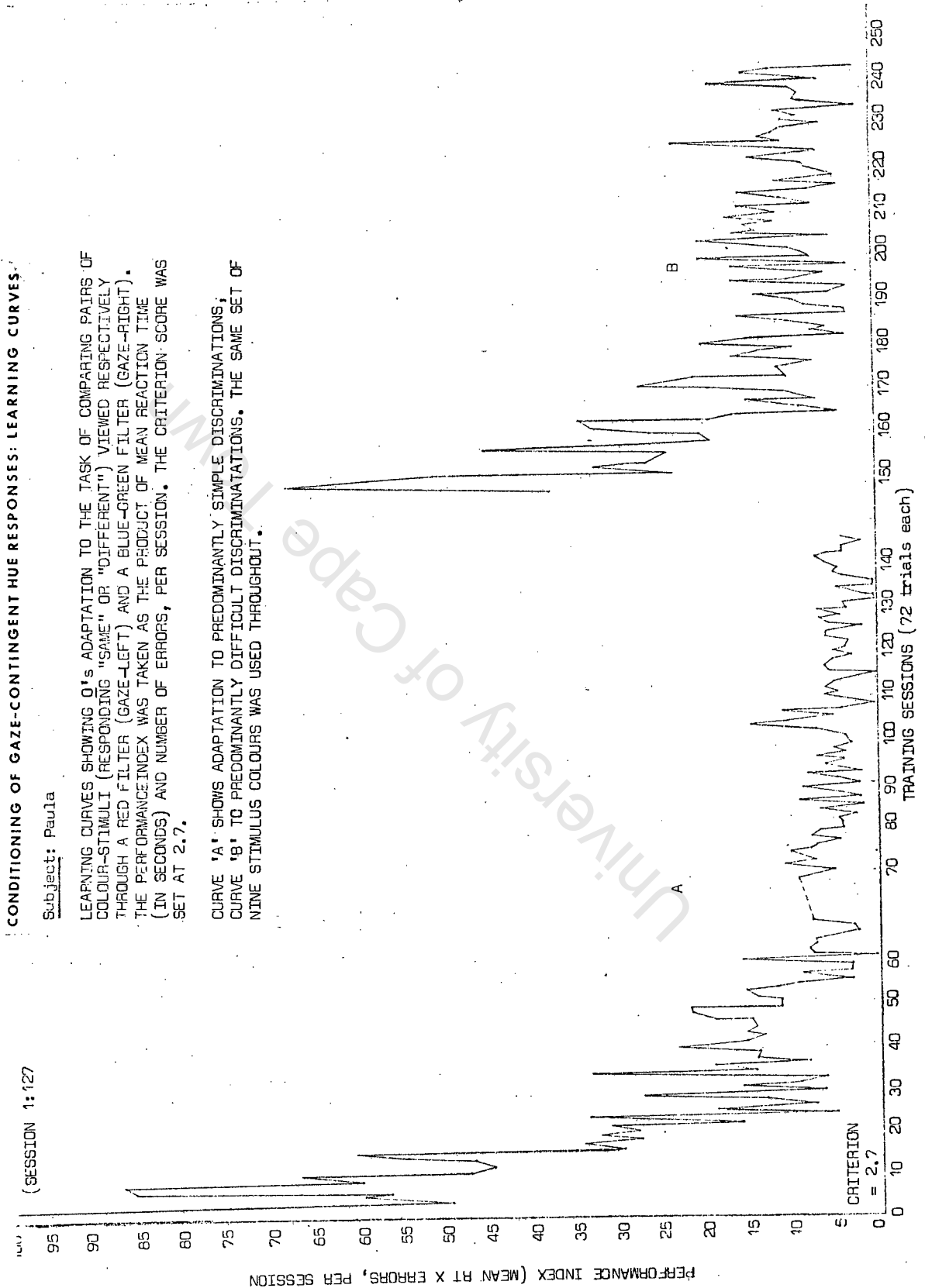
The total time spent on these bogus tasks was 5.6 hours. Details are presented in Appendix 16.

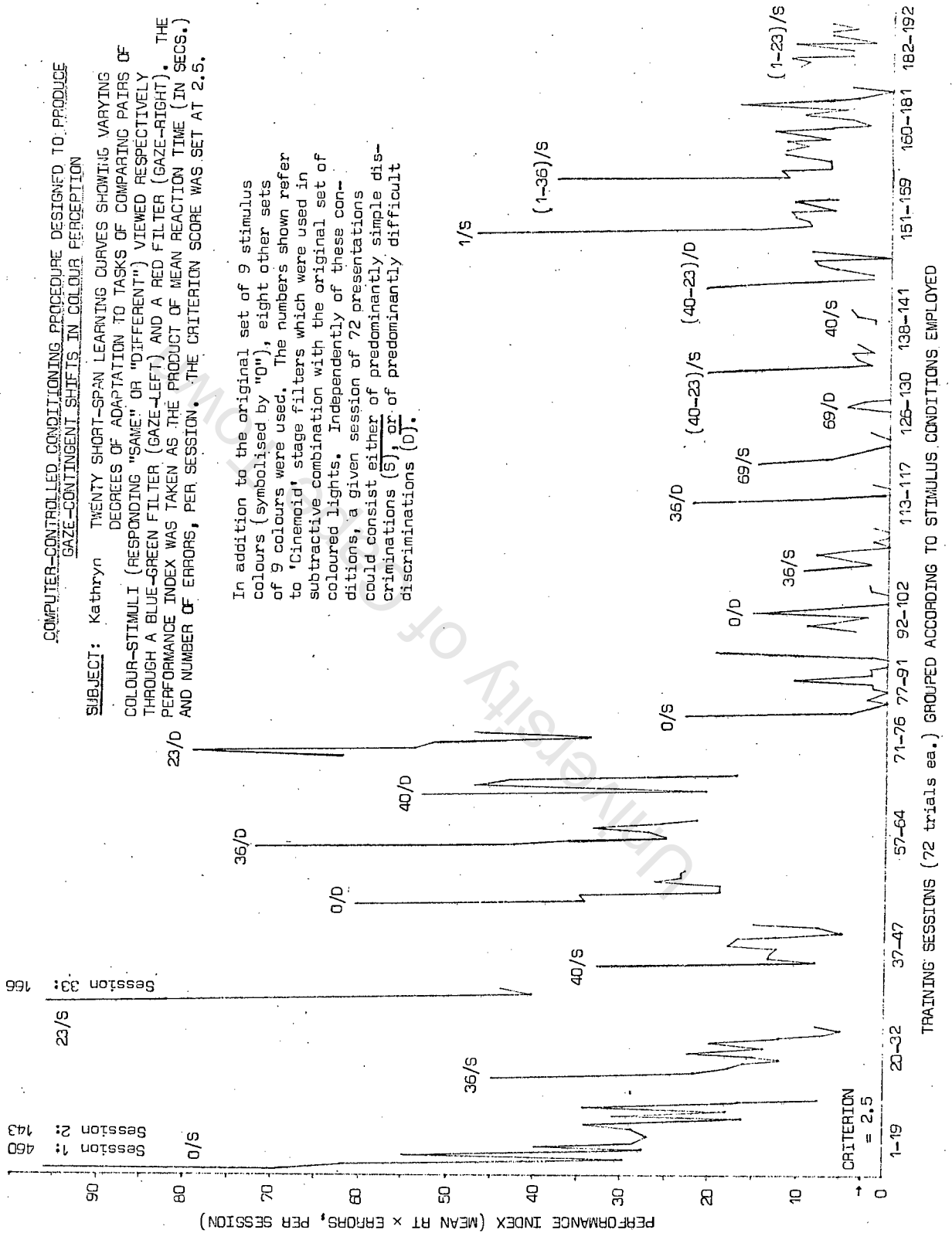
For the experimental sessions proper, the overall strategy with Kathryn differed from that employed with Paula. In the first place, she was never allowed to see the source colours as such, for reasons already given. Secondly, she was not required (except in one instance) to remain at the adaptation criterion for successive trials, whereas Paula was, and tried to. On the other hand, Kathryn was asked to perform more difficult tasks, in that many more than the basic 9 source colours were presented. It will be recalled that for a given three-filter combination the computer could present up to 24 different colours. It was decided, however, to retain the original set of 9 and simply to place different filters inside the colour-mixer against the aperture. Naturally, different filters produced differing degrees of task-difficulty.

Kathryn's learning curves are therefore not commensurate with Paula's, as will be seen from Fig. 14. Instead of Paula's two long-term curves (Fig. 13) Kathryn generated 20 short-term curves. The colours were different and E's requirements were different.

On the testing side, an important (and belated) innovation was introduced. Kathryn's test data are presented in Appendix 12. As with Paula, the method of single stimuli was employed, O being required to make dichotomous ("red" or "green") responses. But when the method of adjustment was tried with Kathryn, her own intra-session variability was so high that the technique provided little or no information. Since it is known (e.g. Jameson & Hurvich, 1951; Hurvich, Jameson and Cohen, 1968) that adaptation effects are materially influenced by stimulus duration, I decided to try to control this difficult variable when using the method of adjustment. A small programme was written which switched off the colour-mixer as O was busy making her adjustment for neutral. This served as her cue to turn her head back to the gaze-forward condition and wait for a tone in the appropriate ear which was the signal to move her head in order to view the colour-mixer and continue with her adjustment. The duration of these intervals was specifiable as a parameter by E, and 4 seconds was found (in dry runs with other subjects) to be optimal. Under these conditions, Kathryn's scatter was considerably reduced, as will be seen from the analysis of her data presented in Appendix 15.

Tables 5, 6, 7 & 8 provide summary analyses of the testing and experimental sessions for both subjects.





CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSIONS: SUMMARY DATA
(Red filter, during training, on gaze-left; Blue-Green filter, during training on gaze-right)

SUBJECT: Paula

REFERENCE	DAY	SERIAL STATUS OF TEST	PURPOSE	VIEWING CONDITIONS & METHOD	RESULT
Data, p. 316 Analysis, p. 356	1	Pre-Experimental	To test laterality bias in viewing system (informal)	Mirrors (No filters)	Estimated mean vernier setting on gaze-left = 46.5 " " " gaze-right = 50.0
Data, p. 317 Analysis, p. 357	1	Do.	To relate characteristics of viewing filters to colour-mixer characteristics	Mirrors Filters in Position	Estimated mean vernier setting on gaze-left, through Red Filter = 71.0; Estimated mean vernier setting on gaze-right through Blue-Green Filter = 32.5
Data, p. 318 Analysis, p. 358	1	Do.	To obtain criteria of speed and accuracy for training phase	Mirrors. Computer-Controlled	Best trial of 4 gave criterion reaction time of 2.7 seconds and 1 error. Performance index (= No. of errors x Mean RT) taken as 2.7
Data, p. 319 Analysis, p. 358	3	After First Experimental Phase, 5.7 hours training	To measure hue responses through filters	Mirrors Filters	Mean vernier setting on gaze-left, through Red Filter = 65.90; Mean vernier setting on gaze-right through Blue-Green Filter = 33.14
Data, p. 320 Analysis, p. 359	3	Do.	To measure after-effect gaze-contingent hue-shift	Mirrors (No filters)	Mean Difference (Right minus Left) in J-units = +2.001; $P < .001$
Data, p. 321 Analysis, p. 321	12	4 days after completion of 9.1 hours training	To obtain qualitative evidence re hue shift	Mirrors Computer-Controlled	0 spontaneously reported that "some colours looked pinker on right-hand side than on left-hand side"
Data, p. 322 Analysis, p. 322	13	Do.	Do.	Do.	Confirmed above, after being asked to make careful judgments
Data, p. 324 Analysis, p. 359	23	3 days after complete programme, 14.9 hrs training	To measure after-effect gaze-contingent hue shift	Mirrors	Mean Difference (Right minus Left) in J-units = +3.565; $P < .001$
Data, p. 325 Analysis, p. 359	23	Do.	To test laterality bias in viewing system	No Mirrors	Mean Difference (Right minus Left) in J-units = +.843; $P < .01$
Data, p. 326 Analysis, p. 360	27	7 days after complete training programme	To test for tone-contingent hue shift (gaze-forward)	No Mirrors	Mean Difference (Right minus Left) in J-units = +.514; $P = .149$
Data, p. 327 Analysis, p. 360	27	Do.	To test for gaze-contingent hue shift without mirrors	No Mirrors	Mean Difference (Right minus Left) in J-units = +1.025; $P < .001$
Data, p. 328 Analysis, p. 360	27	Do.	To test for gaze-contingent hue shift without tones	No Mirrors	Mean Difference (Right minus Left) in J-units = +.513; $P < .05$
Data, p. 329 Analysis, p. 361	55	35 days after completion of training programme	To test for extinction	Mirrors	Mean Difference (Right minus Left) in J-units = +.572; $P < .05$

CONDITIONS OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSIONS: SUMMARY DATA

(Ref filter, during training, on gaze-right; Blue-Green filter, during training, (Maximum Red on Vernier Dial = C on gaze-left) Maximum Blue-Green on Vernier Dial 0 100)

SUBJECT: Kathryn

REFERENCE	DAY	SERIAL STATUS OF TEST	PURPOSE	VIEWING CONDITIONS & METHOD	RESULT
Data, p. 330 Analysis, p. 362	11	3 days after control sessions, total viewing time 5.6 hours	To measure hue-responses contin- gent on gaze	Mirrors Single Stimuli R/G Responses	Mean Difference (Left minus Right) in J-units = -.257; $P = .279$
Data, p. 331 Analysis, p. 362	11	Do.	To measure laterality bias in system	No Mirrors Single Stimuli R/G Responses	Mean Difference (Left minus Right) in J-units = -.361; $P = .241$
Data, p. 332 Analysis, p. 363	23	24 hours after first end of experimental phase (5.9 hours)	To measure gaze-contingent hue- shift after-effect	Mirrors Single Stimuli R/G Responses	Mean Difference (Left minus Right) in J-units = + 1.070; $P < .001$
Data, p. 333 Analysis, p. 363	23	Do.	To measure laterality bias in system	No Mirrors Single Stimuli R/G Responses	Mean Difference (Left minus Right) in J-units = -.104; $P = .774$
Data, p. 334 Analysis, p. 364	49	24 hours after last experimental session (Total training, 11.8 hours)	To measure gaze-contingent hue- shift after-effect	No Mirrors Method of Adjustment	Mean Difference (Left minus Right) in J-units = +1.53; $P < .001$
Data, p. 335 Analysis, p. 364	49	Do.	To measure neutral point, gaze- forward (no tones) and compare with gaze-left and gaze-right (above)	No Mirrors Method of Adjustment Computer-controlled interruptions of viewing	Mean Difference (Forward minus Left) in J-units = -1.93 J-units; $P < .001$ Mean Difference (Forward minus Right) in J-units = -352 J-units; $P = .143$
Data, p. 336 Analysis, p. 365	49	49 hours after final session	To measure gaze-contingent shift without tones in ears	No Mirrors Method of Adjustment	Mean Difference (Left minus Right) in J-units = -805 J-units; $P < .01$
Data, p. 337 Analysis, p. 365	49	Do.	To measure tone-contingent shift without head-turning	No Mirrors Method of Adjustment	Mean Difference (Low minus High) in J-units = -.700 J-units; $P < .01$
Data, p. 338 Analysis, p. 366	50	72 hours after final session	To measure gaze-and-tone contingent hue shift	Mirrors Method of Adjustment	Mean Difference (Left minus Right) in J-units = + 2.12; $P < .001$
Data, p. 339 Analysis, p. 366	50	Do.	Do.	No Mirrors Method of Adjustment	Mean Difference (Left minus Right) in J-units = + .794; $P < .01$
Data, p. 340 Analysis, p. 367	53	6 days after final session	Do.	Mirrors Single Stimuli	Mean Difference (Left minus Right) in J-units = -.453; $P < .05$

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: SUMMARY EXPERIMENTAL DATA
(Analysed from computer printout)

Subject: Paula

Refer to Appendix 14 for full details

DATE	DAY NO.	SESSIONS COMPLETED	NO. OF TRIALS COMPLETED	RANDOMISATION USED	'MATCH ERRORS', MEAN	'MISMATCH ERRORS', MEAN	TOTAL ERRORS, MEAN	OVERALL MEAN RT (SECONDS)	MEAN POST-ERROR INSPECTION TIME (SECS.)	TOTAL SESSION TIME (HOURS)	MEAN PERF. INDEX MEAN RT X TOTAL ERRORS	MISCELLANEOUS NOTES
Feb.												
2	1	22	1584	S	3.5	5.9	9.5	5.3	6.9	2.76	52.3	S = Simple discriminations D = Difficult discriminations
3	2	29	2088	S	1.1	4.0	5.1	3.1	5.6	2.02	15.6	
4	3	16	1152	S	.4	2.1	2.5	2.7	5.9	.96	6.8	
6	5	22	1584	S	.8	1.8	2.6	2.3	4.9	1.07	5.6	
7	6	16	1152	S	1.0	2.3	3.3	1.8	2.8	.63	6.1	
8	7	26	1872	S	.8	1.4	2.2	1.9	2.3	1.01	4.1	
9	8	14	1008	S	.5	1.4	1.9	2.1	2.4	.61	3.7	
14	13	14	1008	D	2.1	7.5	9.6	3.5	3.8	1.13	34.3	
15	14	16	1152	D	.9	3.5	4.4	3.6	3.7	1.22	15.6	
16	15	17	1224	D	.6	2.5	3.2	2.9	4.2	1.04	9.3	
17	16	15	1080	D	1.2	3.1	4.3	2.8	2.9	.87	11.6	
20	19	20	1440	D	1.9	2.8	4.7	2.2	1.4	.94	10.4	
21	20	15	1080	D	1.3	2.9	4.2	2.1	1.2	.66	8.9	
-	-	18.6	1162	-	1.2	3.2	4.4	2.8	3.7	1.15	14.2	MEANS
	(13)	242	17424	-	-	-	-	-	-	14.9	-	TOTALS

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: SUMMARY EXPERIMENTAL DATA

(Analysed from computer printout)

Subject: Kathryn

Refer to Appendix 14 for full details

DATE	DAY NO.	SESSIONS COMPLETED	NO. OF TRIALS COMPLETED	RANDOMISATION USED	'MATCH ERRORS', MEAN	'MISMATCH ERRORS', MEAN	TOTAL ERRORS, MEAN	OVERALL MEAN RT (SECONDS)	MEAN POST-ERROR INSPECTION TIME (SECS.)	TOTAL SESSION TIME (HOURS)	MEAN PERF. INDEX	MEAN RT X TOTAL ERRORS	MISCELLANEOUS NOTES
April													
7	1	8	576		-	-	-	5.3	-	.85	-	-	Pre-training
10	4	11	792		-	-	-	4.3	-	.95	-	-	Control
11	5	6	432		-	-	-	11.3	-	1.35	-	-	Sessions
12	6	6	432		-	-	-	9.4	-	1.13	-	-	
14	8	4	288		-	-	-	16.5	-	1.32	-	-	
-	-	7	504	-	-	-	-	9.4	-	1.12	-	-	Means
-	(5)	35	2520	-	-	-	-	-	-	5.60	-	-	Totals
18	12	19	1368	S	2.5	8.8	11.3	4.5	3.9	1.99	62.8	-	Experimental
20	14	6	432	S	3.3	3.7	7.0	2.9	3.3	.41	21.3	-	Training
21	15	11	792	S	3.7	5.7	9.5	3.2	4.2	.86	38.3	-	Sessions
24	18	11	792	S	2.7	2.7	5.5	2.6	4.1	.64	14.1	-	
25	19	9	648	D	3.1	7.3	10.4	2.8	4.4	.62	29.4	-	S = Simple
27	21	8	576	D	4.1	7.9	12.0	2.9	7.0	.57	35.5	-	Discrimi-
28	22	12	864	D	4.4	9.8	14.2	3.1	4.4	.95	44.6	-	nations
May													
8	32	15	1080	S	1.1	1.1	2.1	2.2	2.9	.73	5.2	-	D = Difficult
9	33	11	792	D	.5	1.5	1.9	2.3	2.5	.52	4.5	-	Discrimi-
10	34	3	216	S	1.0	1.3	2.3	2.3	3.9	.15	5.5	-	nations
12	36	12	864	S/D	.2	.9	1.1	1.0	1.2	.57	2.7	-	
15	39	13	936	S/D	.8	.4	1.2	2.4	2.3	.64	3.0	-	
16	40	11	792	S	1.1	1.0	2.1	2.5	4.3	.53	5.1	-	
17	41	9	648	D	1.4	1.9	3.3	2.2	4.7	.45	7.9	-	
18	42	9	648	S	2.8	2.9	5.7	2.4	4.6	.50	14.3	-	
19	43	11	792	S	2.5	2.5	5.1	2.4	3.9	.60	12.4	-	
22	46	11	792	S	1.6	1.2	2.8	2.4	3.1	.57	7.1	-	
23	47	11	792	S	1.2	1.9	3.1	2.3	3.6	.54	7.1	-	
-	-	10.7	768	-	2.1	3.5	5.6	2.6	3.8	.66	17.8	-	Means
		192	13,824	-	-	-	-	-	-	11.8	-	-	Totals

4.8 Results

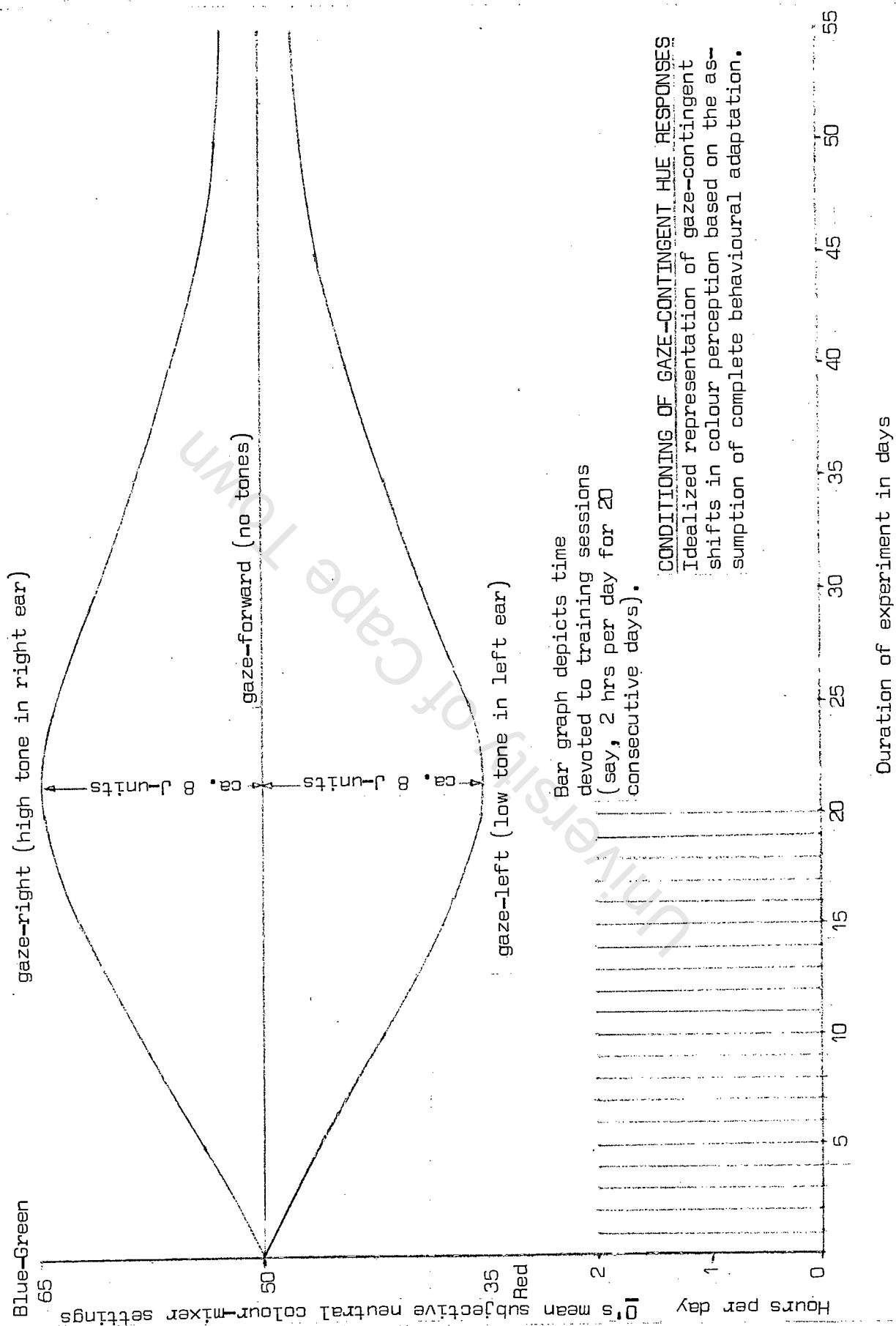
The reader examining the data presented in Appendixes 11 to 16 for Paula and Kathryn can be forgiven for feeling confused by the welter of detail that needs to be assimilated. It was certainly not my intention, at the outset of this experiment, to manipulate so many variables. Indeed, I had looked forward to a quick, neat and elegant demonstration of the Kohler-effect as a result of the specific training methods which Taylor's hypothesis requires. I believe that the results obtained do in fact strongly support this hypothesis and I shall argue this point in a later section. But, giving an overview of all the data quickly, neatly and elegantly, is going to be no easy task.

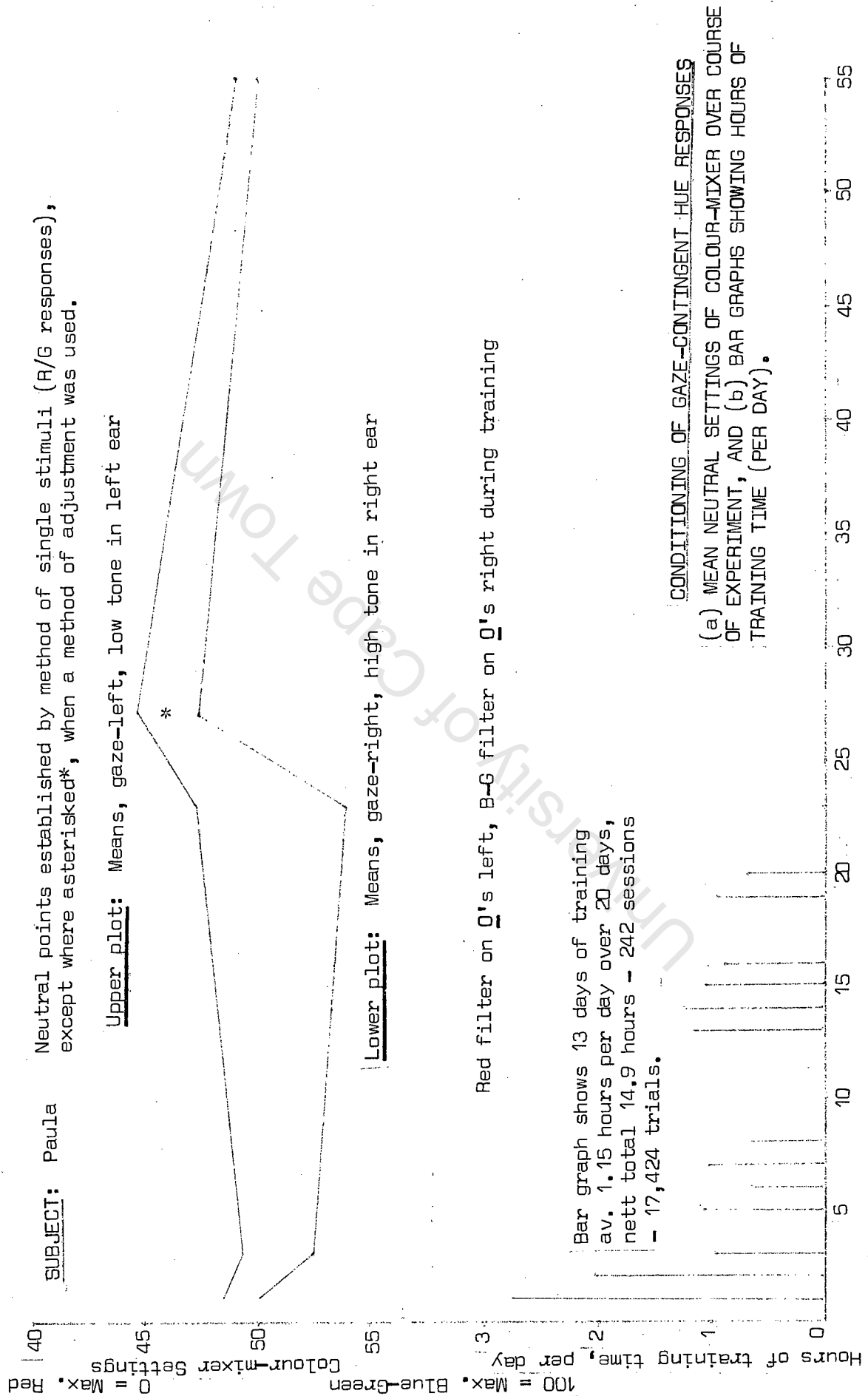
What I feel obliged to do is first to present an "ideal" outcome (in graphic form) of what might have been expected, had things turned out flawlessly and impeccably. I shall then present the main findings and compare them with the idealised picture, discussing points of departure. Only after this has been done will it be expedient to return to subsidiary evidence, some of which, I shall be prepared to concede, have an anomalous or at least debatable status.

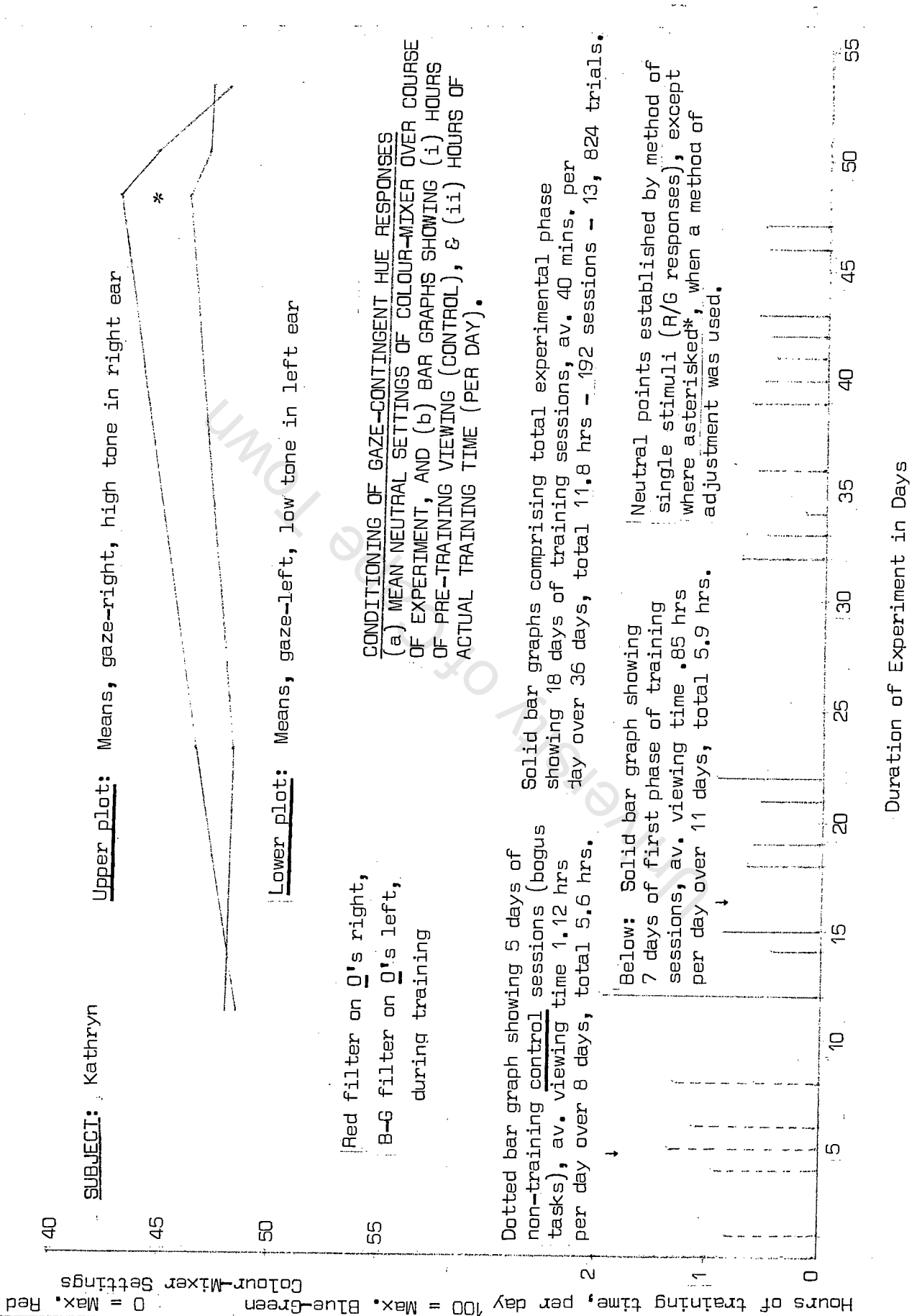
Let us try to imagine an idealized picture of the gaze-contingent shifts in colour perception that might be expected on the assumption of complete behavioural adaptation of the kind demanded by a literal interpretation of Taylor's hypothesis. Suppose that we have a subject whose neutral setting on the colour-mixer, prior to training and regardless of gaze-direction, is 50 (setting for maximum red saturation = 0; for maximum blue-green saturation = 100). Let us assume that she needs about 20 training periods of two hours each in order to reach complete adaptation. That is to say, her responses on the task described in Fig. 11 with the filters in position, differed in no way, in terms of both accuracy and speed, with the responses she makes without filters or with neutral density filters. Suppose, further, that no extinction or counter-conditioning occurs outside the laboratory between these training sessions. Now the maximum possible gaze-contingent hue-shift is determined by the transmission characteristics of the viewing filters. In the case of those used with Paula (red on gaze-left and blue-green on gaze-right) her own mean neutral settings, as shown in Table are 65.9 and 33.1 respectively. If we adopt 65 and 35 as our maxima then the expected curves might appear something like those shown in Fig. 15.

The bar-graph in Fig. 15 shows 20 x 2-hour training sessions over a period of about 24 days. There are three plots of the subject's neutral settings. They all start at 50, but only in the gaze-forward condition does it remain at 50 over the period graphed (45 days). For the gaze-right condition the neutral settings steadily shift to a "maximum" of 65 (what, in the gaze-forward condition, she would call a good blue-green); while those for gaze-left show a mirror-image shift to a "maximum" of 35 (what in the gaze-forward condition she would call a fairly deep pink).

Now refer to the actual plots obtained of mean neutral settings for gaze-left and gaze-right for Paula and Kathryn, Fig. 16 and Fig. 17. (The corresponding graphs for the medians are shown in Appendix 17, but since they are very similar to the means, I shall not refer to them in the discussion that follows.)







What are the differences between the real and the ideal?

1. Both our subjects' plots, but especially Kathryn's, seem sadly attenuated and distorted.
2. No plot is shown of gaze-forward (sans tone). We cannot, by inspecting the two pairs of plots, determine whether there was a bilateral shift from gaze-forward.

What we need to determine now is whether these differences reflect a fundamental discrepancy, a basic irreconcilability; or whether they merely testify to an inequality in magnitude or degree.

In order to get one question out of the way for the time being, let us anticipate by saying that, as far as the laterality of the after-effects is concerned, although there were significant hue shifts, in the predicted direction, for both subjects, between gaze-left and gaze-right, this did not appear to be the case between gaze-left and gaze-forward in Paula's case, nor between gaze-right and gaze-forward in Kathryn's case. To put it another way, the major shift, for both subjects was unilateral; to the right in Paula's case and to the left in Kathryn's case⁵. We shall of course have to investigate this anomaly and decide whether, on its own, it imperils the overall hypothesis.

For the moment, let us concentrate on the actual size, in psychological or psychophysical terms, of the differences in hue perception between gaze-left and gaze-right.

That the issue is not as straightforward as this has already been touched on*in discussing the possibility of the so-called "experimenter effect" having operated (in favour of the hypothesis) in Paula's case. But there is a further complication, and again it was one which operated to the advantage of the hypothesis. After Paula's first results began to be analysed it became clear that there was a small, but systematic laterality bias in the viewing system such that the gaze-right neutral point needed slightly more green than the gaze-left neutral point.

I shall discuss the probable magnitude of the "experimenter-effect" in a later section. What we need now is a psychophysical estimation of the gaze-contingent differences for the two subjects over the whole

*see p. 184

course of the experiment, corrected for the artifactual bias mentioned above. Our obvious recourse is to the J-unit measures described in the previous tone-contingent study, and on this basis it can be said that for Paula this was reliably shown to measure not less than half a J-unit and not more than a full J-unit. In Kathryn's case, however, it (usually) less than half a J-unit and not reliably so. Now the filters, it should be remembered, were red on the left and blue-green on the right for Paula; but the other way around for Kathryn. So the bias operated to the disadvantage of the hypothesis in Kathryn's case. If we plot a curve showing the nett J-unit differences for the two subjects, I suggest that justice will be done if we subtract 0.7 of a J-unit from Paula's results and add 0.4 of a J-unit to Kathryn's.

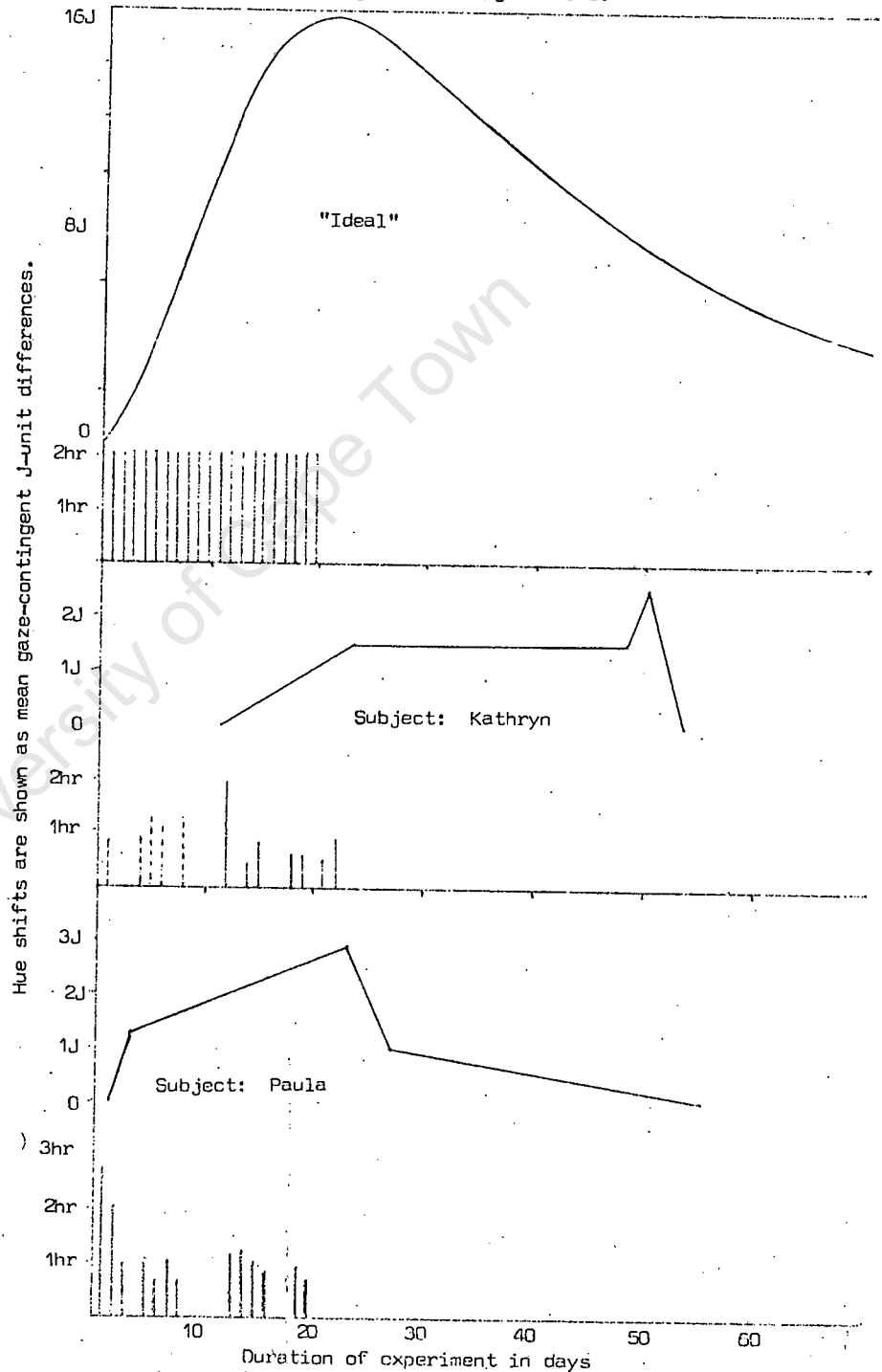
This move is reflected in the curves for the two subjects in Fig. 18 showing the nett J-unit differences between gaze-left neutral and gaze-right neutral, and it is these (and the training bar graphs) which we must compare with the corresponding "ideal" case.

Sheer amplitude aside, what are the similarities between the ideal and the real?

1. All the obtained after-effect differences are in the right direction: they are vectorially consistent with the behavioural hypothesis.
2. In Paula's case, after 5.8 hours of training over three days, we have a nett difference of 1.3 J-units ($P < .001$).
3. In Kathryn's case, after 5.6 hours of pre-training control sessions (involving the bogus tasks previously described) the J-unit difference is an effective zero.
4. After Kathryn's initial training phase comprising 5.9 hours over 11 days there is a nett difference of 1.5 J-units ($P < .001$). This difference is comparable with Paula's, but what is more to the point, it comes after a training time which is comparable both with her own control phase (5.6 hours) and with Paula's initial training phase (5.8 hours).

CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: COMPARISON OF "IDEAL" REPRESENTATION OF GAZE-CONTINGENT SHIFTS IN COLOUR PERCEPTION (ON THE ASSUMPTION OF "COMPLETE" BEHAVIOURAL ADAPTATION) WITH SHIFTS ACTUALLY SHOWN BY TWO SUBJECTS.

Solid bar graphs in each case depict no. of hours of actual training time. Dotted bar graph (for one subject only) shows no. of hours of pre-training control sessions involving various bogus tasks.



There is, therefore, good evidence that merely inspecting the stimuli and describing them, or carrying out any other task which is irrelevant to the primary requirement that Q should learn to make the same response to the same stimulus whether viewed through the red or the green filter, is not sufficient to bring about a tone-contingent after-effect hue shift.

5. Moreover, as training proceeds, the shift becomes larger. For Paula, after a further 9.1 hour's training, the nett shift increases to 2.9 J-units. For Kathryn, after a further 5.9 hour's training, the nett shift goes up to 1.5 J-units (not corrected for laterality bias here, because in this test the viewing angle was perpendicular to the colour-mixer and the mirrors were dispensed with).
6. Finally, as training ceases, the hue shift diminishes.

In the real case this diminution is more drastic than in the ideal but, in the former, we have to take into account the long, non-reinforced testing sessions that both Paula and Kathryn (but especially Kathryn) were subjected to.

This completes an account of the main body of evidence which, I shall argue, lends strong support to the behavioural hypothesis concerning the necessary and sufficient conditions for the production of a gaze-contingent change in hue perception.

Before going on to subsidiary findings I should like to examine more closely the conditions of the experiment in the light of,

- (a) the fact that with both subjects there was no bilateral hue shift from the gaze-forward condition, and
- (b) the fact that the hue shifts obtained were, psychophysically, not at all large

Notes

5. When conveying these findings to the 24th Annual Congress of the South African Psychological Association, July 1972, I mistakenly reported Kathryn's shift as being on gaze-right instead of gaze-left.

4.9 Analysis of Principal Findings

On questioning Paula after it was established (on day 23) that there was no effective hue shift between gaze-left and gaze-forward, she revealed that her technique of mastering the task was to inspect x_1 (i.e. the first member of the stimulus-pair after transformation by the red filter) and then make a prediction concerning what y_2 should look like on the hypothesis that x and y were identical (at the unseen source, of course). She would then move her head to the right and her response-readiness of saying "same" (and pressing the appropriate key) was geared to this prediction. That is to say, she used the gaze-left appearance of the colours as her origin or zero or veridical, and the gaze-right appearances were the ones that she made her verbal and motor responses to and was reinforced for, so that a new constancy developed for gaze-right, but not for gaze-left.

In Kathryn's case, exactly the same thing occurred, but this time she used gaze-right as her reference point, and so her gaze-left perceptions underwent a transformation⁶.

I can expect this explanation to meet with some scepticism, so it is necessary to debate the matter at greater length.

Let us recall the conditions of the experiment. The subject sees each transformed colour on turning her head, to left and to right respectively, and in no other way. On gaze-forward she sees nothing

because (a) there is an opaque screen in front of her, and (b) because in any case the computer switches in the appropriate resistances only when the head is turned. There is thus no response which Q can meaningfully make in the gaze-forward condition throughout the entire training programme. We can expect, therefore, that this gaze-condition will be indeterminate with respect to the hue shift after-effect.

It could be objected that what we have every right to expect is that Q's hue responses in the gaze-forward condition should remain stable (within the limits of normal oscillation) at their pre-experimental level. In fact, this is what I myself tacitly assumed would occur. But I was not taking Taylor's axioms literally enough. Perception is a state of simultaneous multiple readiness for all of the responses that have been conditioned to the total afferent input operating at the moment. We cannot assume that, after 10,000 trials or more in the training situation, the "total afferent input" remains unchanged for the gaze-forward condition. Until Q began the experiment such afferents as are associated with sitting in a dark room with headphones on, constantly turning the head, receiving concomitant tonal and visual stimulation of a very specific kind, being oriented towards a very unusual task, making key-pressing responses which resulted in a constant succession of favourable and unfavourable feedback signals, and so on, were simply not part of his normal inputs. The behavioural hypothesis that colour-perception contingent on gaze-left will be different from that on gaze-right derives from the specific differences in response-readinesses that results from adaptation to the task. What we cannot do is make predictions about how elements of the new response readinesses required will affect the perception of hue in the gaze-forward condition.

Let me be more specific. Suppose that the contingencies of the experiment had been such that Q saw each colour selectively transformed on gaze-left and gaze-right, but non-selectively transformed (i.e. through a neutral density filter) on gaze-forward. The behavioural theory would then generate the prediction that adaptation to each condition would result in a bilateral perceptual shift. (In retrospect, I might have proceeded by training Q with a neutral density filter F_n paired (and alternated) on successive sessions with the chromatic filters, F_1 and F_2 , in such a way that F_1 was always on the left when F_n was on the right, and F_2 was always on the right when F_n was on the left. I think that this would have ensured a bilateral after-effect, but in

this case it still might not have ensured the determinacy of gaze-forward responses, since they would have been absent in the conditioning procedure.)

If this argument is sound, it means that the "ideal" outcome depicted on p.202 was ideal in a pejorative sense of that term, i.e. it was unreal: it proceeded from a set of assumptions that had not been sufficiently carefully thought out before the experiment was embarked upon. It underlines Taylor's insistence that psychologists should not be ashamed of using the armchair in order (a) to specify their axiomatic premises, and (b) to examine strictly and literally, the logical entailments of these premises when applied to a set of actual conditions.

We can now devote attention to what is probably the more important issue. Why, after achieving apparently good levels of adaptation, did both subjects, but especially Kathryn, show such meagre after-effects? Meagre, that is, in amplitude; their statistical reliability is not in question. In fact, I specifically computed the confidence levels to a large number of decimal places (using a special programme for the purpose) in order to bring home the fact that even when one could state that the probability of the difference being due to chance was virtually zero (the lowest P value was less than 1×10^{-8}) the extent of the difference, in psychophysical terms, could be quite small. It was this "discovery" which prompted me to analyse Howells' results in psychophysical terms and establish how small his reported tone-contingent shift really was.

Before going any further, there is one fact that I regard as established, and that is Paula's spontaneous comment on Day 12 that some of the colours which she knew were supposed to be identical looked pinker on the right than on the left. By this I mean that I have had no reason to doubt the validity of her report. At that stage she had no idea of my objectives, so an experimenter-effect explanation is ruled out. What is also ruled out is the laterality bias in the viewing system, since this was a function of the two-colour mixer's characteristics whereas it was the three-colour mixer which was used in the computer-controlled comparison test during which she experienced the effect. Having performed the comparison test before training had commenced, her own deduction was that a fault had developed in the apparatus.

When, on the next day, she was specifically asked to scrutinize the colours, she made the same report. But on this occasion, as she told me afterwards, she believed that I was hoping for some such result. Nevertheless, she strongly maintained that this hue-differential was quite marked and could not, at that stage, have had anything to do with her thoughts about my aims.

I cannot be too emphatic about this: against the profusion of numerical data that has been so laboriously marshalled in order to quantify the evidence in both studies, Paula's description of her experience stands out in a very special way. "The language in which the subject of an experiment on perception reports his acts of knowing is a set of pointer-readings by which those acts may be publicly known" (Taylor, 1962, p.353). It was Mike's language (two words in fact) in the tone-contingent study, that enabled me to reject the impressive quantitative data as evidence of an alteration in visual perception. In human perception this is the final touchstone. I am not suggesting that we can let the matter rest here. "The question of the relation between report and experience is one of the most complex that mankind could well raise", Sigmund Koch remarked at a famous symposium (Wann, 1964, p.162).

Which brings us to Paula's subsequent test data. For the most part the procedure I used with her was a method of single stimuli, and requiring responses of "red" or "green" from Q (guessing not discouraged). Now in such a test, the honest subject who knows what the experimental aims are, and has a bias in favour of E, not against him, is in a difficult position. As Paula put it to me afterwards, "I really did try to describe the colours as I saw them, but the in-between ones don't fit into either category, and I simply wasn't sure whether or not I was being influenced by my knowledge of the results you wanted". Anyone who has had occasion to act as a subject in a forced-choice test of this kind will appreciate how, as a liminal point is approached, one snatches at straws. The question is: by how much did it affect the data? I venture to assert, by no significant amount. That is, I believe that her previous spontaneous qualitative report (after 10,000 trials) is fully consonant with the fact that a perceptible shift had occurred (after 17,000 trials) which I have computed as 2.9 J-units nett. On this note I will rest my case about the validity of Paula's results.

My anxieties on this score were such, however, that I was determined that my next subject should not become aware of my aims. I therefore departed in certain ways from the procedures used with Paula. Not until the 50th (penultimate) experimental day did Kathryn have an inkling of the fact that I was interested in the effect of the tones on her colour perception (about which more later). But the departures I introduced may have had an important bearing on her comparatively small hue-perception changes.

I believe that the most important of these departures was that whereas Paula saw the original source colours (i.e. without viewing filters) over several hundred presentations, Kathryn never did. On being questioned, Paula revealed that she used her knowledge in the following way: " x_1 (gaze-left) must be the purple (say). If y_2 (gaze-right) is also the purple it will have to appear so-and-so". If y_2 does have this appearance and her response is correct, her verbal reactions are, " x_1 is (really) P; y_2 is also P; therefore 'same'". Paula was therefore (on some occasions, at least) not merely learning to say "same" or "different" and press the appropriate keys; she was learning to direct a unique (if covert) tagging response to the same objective stimulus through whichever filter it was viewed.

Kathryn, on the other hand, was able to identify the x_1 's and y_2 's by labelling them in some idiosyncratic way (much of her time was spent in doing just this during the control phase). Although it is true that she knew that there was a blue-green filter on her left and a red filter on her right (they were pointed out to her at the beginning of the experiment and of course she saw them before and after every session) she could not, except partially, by a rough computation, say to herself, " x_1 is really a P; y_2 is really a P; therefore, $x = y$ ".* She used the same predictive method as Paula (in spite of my attempts to prevent her from doing so), but the manner in which she used it was to learn, so she disclosed, "what went with what". Thus: " x_1 is P; P goes with Q; to be the 'same' y_2 will have to be Q". This verbal rigmarole contains the very ingredients necessary to inhibit the formation of new modes of responding and therefore of perceiving. That Kathryn's results were significant at all must mean that to some small extent she was able to make the kind of computation that featured in Paula's case, using an approximate method of computation on the basis

* Kathryn did not have the benefit of the white "pilot light" (see p.212).

of her knowledge that the filters were blue-green and red respectively.

The other problem about the difference between Kathryn's and Paula's results is the kind of learning curves they each generated. There are at least four confounding variables at work, and it is not easy to sort them out:-

- (a) Paula completed 13 days of training, averaging 1.15 hours per day over 20 days, giving a total of 17,424 trials. Kathryn's 13,824 trials were performed in 18 days of training sessions spread over 36 days, averaging only 40 minutes per day.
- (b) In addition to the original set of nine source colours (which were all that were used in Paula's case) Kathryn was exposed to eight other sets of nine at different times during the training programme (see Fig. 14, p.194). These additional sets bore an invariant relationship to the original nine, however, in that each colour in the set was transformed by the filter (or filters) placed at the opening of the three-colour mixer.
- (c) In Paula's case, there was a 1° white "pilot light" situated about 2° below the three-colour mixer aperture. Through the red filter on the left, it appeared a pale pink; through the blue-green filter on the right a light turquoise. In Kathryn's case, this light was disconnected. So Paula had an additional constant and important clue concerning the filters' transmission characteristics which was denied to Kathryn.
- (d) Kathryn was not asked (except for one or two brief stints) to remain at the adaptation criterion for successive trials whereas this was made the prime target for Paula. Kathryn's increments of learning were certainly larger than Paula's, on more difficult tasks, but she quickly became bored and her interest could be re-aroused only by offering her "new colours".

Inspection of their learning curves in Figs. 13 and 14 and of Tables 5 and 6 shows that Kathryn was quicker and more apt at the task (in fact her colour discrimination as measured by the Farnsworth-Munsell test was better than Paula's, although the latter's was within normal limits.)

The problem here, it should be noted, is one which belongs in the realm of learning theory, not perception. We have to evaluate Paula's larger mass of trials concentrated over a smaller period against Kathryn's rather thinly distributed sessions interrupted by the seven day mid-term vacation which may have lead to at least partial extinction. The longest period over which the gaze-contingent after-effect was observed was in fact seven days, in Paula's case, and this was a nett shift of only one J-unit. If the same rate of extinction operated in Kathryn's case, it would mean that she had to start "from scratch" on Day 32, resulting in only another 5.9 hours of training. Opposed to this we have Kathryn's better rate of adaptation, but lacking the approximately asymptotic characteristic of the classical learning curve to which a physiological limit applies.

If we try to weigh these conflicting factors, I think it has to be said that these two performances are incommensurable. Nevertheless, I believe that in future work one would certainly want to avoid the distribution pattern of Kathryn's trials, and to insist on the criterion being maintained over a reasonable span of trials.

Finally, the constant presence of a white light in conjunction with the source-stimuli would seem to be an obvious facilitator of the kind of adaptation that Q needs to acquire.

To complete the analysis of the gaze-contingent data, we turn to subsidiary test results which at first I found difficult to interpret.

Notes

6. I would venture to say that the control phase, by itself, must have hindered the formation of responses of the kind

" x_1 is (really) P; y_2 is (really) P; therefore, $x = y$ ".

4.10 Analysis of Subsidiary Data

In this study I have spoken all along of "gaze-contingent" responses (and perception). To be precise, I should of course have used the more accurate, if more cumbersome expression, "gaze-and-tone-contingent", since these were the non-chromatic afferents which, with the proximal photic stimuli, constituted the compound input to which the responses were to be conditioned. The motive for introducing the tonal stimuli, as I have already said, was to make this input as distinctive as possible, and so minimise extinction tendencies outside the laboratory situation.

I was interested, after the main tests were performed, to see whether there would be (a) a purely gaze-contingent hue-shift, and (b) a purely tone-contingent hue-shift.

At the time I predicted that such shifts would occur on the basis of stimulus generalization in the predicted direction but to an attenuated degree.

A glance at Tables 7 and 8 on p.197a and 197b will show that

- (a) for Paula, on Day 27, the main neutral point difference was .514 J-units in the predicted direction (but not reliably so, $P = .149$) for a tone-contingent hue shift, whereas it was .513 J-units, also in the predicted direction ($P < .05$)

for a purely gaze-contingent shift. (Note that in these cases, having dispensed with the mirrors, a correction for laterality bias was not necessary).

- (b) for Kathryn, on Day 49, the mean difference was .805 J-units in the direction opposite to that predicted ($P < .01$) for a gaze-contingent shift, and .700, J-units again in the opposite direction ($P < .01$), for a tone-contingent shift.

Of the four sets of data, only that of Paula's, for the purely gaze-contingent condition, conformed to my prediction. In Kathryn's case, both tests yielded data which went (reliably) counter to the predictions.

My first reaction was to conclude that these results rendered the main experimental hypothesis difficult to sustain, but I do not now believe that this is necessarily so.

The matter can be put quite succinctly. If it is the case that one can predict, by learning principles, that these alterations of the compound afferent input should result in generalization rather than discrimination then the hypothesis is disconfirmed; if, on the other hand, a discrimination should result, then the hypothesis survives.

Apart from this, Kathryn's own report in connection with her gaze-contingent result is noteworthy: "When you tested me without the headphones I got the idea that you were interested in the effect that the tones had on the colours. Until then I had been oblivious of the tones. Now I noticed their absence".

I think this observation has important implications for our understanding of the Kohler-effect. If contractions of the eye and neck muscles are, as Taylor maintains, part of the amalgamated input without which the after-effect cannot occur, it is important that these afferents do not themselves become the objects of O's attention; for in that case there is a change of drive, which in itself will alter the total input (which always includes interoceptive afferents) and will therefore in turn affect O's response-readiness in (from E's point of view) an unpredictable fashion.

The same kind of phenomenon can be shown to have taken place by comparing Kathryn's results when the usual viewing system was employed and when it was dispensed with, as on Day 50 (the day after these apparently anomalous results). The mean difference in her neutral points, via the mirrors, was 2.12 J-units ($P < .001$); without the mirrors it was only .794 J-units ($P < .01$). This, in my opinion, strongly confirms Taylor's injunction that one has to examine every aspect of the "total afferent input" before one ventures to make predictions about O's perception.

We could sum up this whole argument by saying that if E wanted to ensure that generalizations of the kinds mentioned should take place, then there should be intermittent modifications of input during training. For example, if on half the trials (randomly assigned) no tones accompanied head-movements, then, given that adaptation occurs notwithstanding, we would expect a perceptual modification that was contingent on head-movements whether or not the relevant tones were present.

4.11 Interpretations and Discussion

I have already said enough, I hope, to convince the reader that Taylor's hypotheses concerning the necessary and sufficient conditions for the elicitation of the Kohler-effect have been amply supported. When interpreting the results of my Howells experiments, I did not have to go further afield than Howells' own data and relate them to mine (and to the Cape Town results in general). In the case of the Kohler experiments, I have an obvious obligation to look at my results within the broader context of other, mainly negative, findings. Just as Stratton's experiment served to initiate a new paradigm for space perception, so Kohler's (1951) "hunch", reported (by Erismann, 1947) half a century later, must surely be recorded as a landmark in the history of our understanding of colour. The ingeniousness of the experiment becomes even more apparent when we try to devise alternative colour analogues of the large variety of space-distorting spectacles that have been in use. Until our technology reaches a more advanced point (so that colours could be seen as their complementaries, for example), it seems that the basic technique will stand intact.

On the theoretical side, I believe that the Kohler-effect will one day be incorporated into a finely-articulated cybernetic model of colour perception, the seeds of which have already been sown by Taylor. Only Taylor's paradigm could have led to the computer-controlled experiments I have reported, and only via that paradigm, I would claim, can we make any sense of them. I have tried hard to arrive at other modes of inter-

pretation and have failed. The failure may be due to my own limitations and, since this is the first detailed account of them, I have had virtually no opportunity to assess explanations from other quarters. It may be no coincidence that the original Howells-effect has also not elicited interpretations outside Taylor's framework. In different ways the original data of Howells and Kohler have virtually defied any other conceptualization.

I should mention in this regard that I have not read the original thesis on which Harrington's (1965) paper is based, and it is possible that he essayed, as did McCollough (1965), to give a theoretical formulation of the Kohler-effect which is at variance with Taylor's. But there are at least three grounds for doubting it. Firstly, he himself comes to the conclusion that the effect is of physiological rather than psychological significance. Secondly, McCollough who, from internal evidence, was acquainted with this thesis, makes no mention of an alternative framework. Thirdly, Harrington obtained his filters directly from Kohler, and since Kohler (1951, 1964) gives no explicit account of the necessary and sufficient conditions for obtaining the effect, we must assume that everyone (except Taylor) took it for granted that merely wearing the spectacles was all that was demanded of Q.

I have already mentioned that Taylor himself (1962, p.255-259) is open to misinterpretation on this point. The reader who does not acquaint himself with Taylor's axiomatic basis can, as McCollough did, assume that Taylor supported Kohler's ill-defined "conditioned sensation" theory. Moreover, Taylor's account in that work does not make it explicit enough that the modes of environmental interaction essential to his thesis must have occurred fortuitously in Kohler's case. Taylor seems to have taken it for granted that if Q did wear such spectacles he could not but experience the adaptational effects postulated. If we read his own theoretical construction again, however, we are left in no doubt that the mechanism is most explicitly enunciated.

But the fact that one of Harrington's subjects failed to evince the phenomenon after wearing such spectacles continuously for nearly five months, cannot be glossed over, in spite of Taylor's (1971) own demurral.

Bearing in mind the control experiment performed on my second subject (Kathryn) in which intent inspection of each (selectively transformed) colour-stimulus produced no gaze-contingent shift in hue perception, it is possible to speculate on the reasons for both Harrington's and McCollough's negative results. If the reader has accepted my postulate of verbal "mediates" in connection with the Howells results, (see p.151) a cogent explanation immediately suggests itself. Let me try to express it afresh in the present context.

In terms of Taylor's developmental theory, the pristine reaction to a coloured object is not to its colour per se but to some property of the object which is of value or utility to the organism. Much of our confusion about colour, he says, arises

...from the erroneous assumption that what we are reacting to when we see a color is the wave length of light. It is nothing of the kind. The wave length of the light is a matter of no consequence to us until we begin studying physics. Prior to that we learn to react to some property of the object reflecting the light, and that is invariably a property that is directly relevant to our own needs as living organisms. When we pick the red tomatoes from the plant and leave the green ones, it is not longer wavelengths that we are selecting but tomatoes that will be good to eat.

(Taylor, 1962, p.344)

I should like to suggest that we can go further than this. It may have been the case that the four subjects in McCollough's and Harrington's experiments were interested in wave-lengths and that their "mediates" were verbal responses of the kind, "When I turn my eyes to the left the wall has an appearance which I would judge, corresponds to x,y co-ordinates of 0.2 and 0.4 on the CIE Chromaticity Diagram whereas, on turning my eyes to the right, the corresponding co-ordinates are approximately 0.5 and 0.3". The supervention of such responses would ensure the inhibition of immediacy even if these subjects were trying to achieve the kind of adaptation Taylor's theory calls for. But it is highly unlikely that such responses occurred to any great extent, even if all of them were keen colour scientists.

But over against this kind of reaction, if we asked an artist or poet who was innocent of physics to wear such spectacles, we should not be surprised to find the same negative result in the end. In his case, the mediate would be of a different order. "The wall, as I turn my eyes to the left, has the plangent iridescence of sapphire; on my right it takes on the bloom of a sultry cyclamen". But no artist or poet could keep up this kind of gush for a week, let alone five months.

Exaggeration aside, my first contention, in brief, is that any normal adult who is at all interested in colour, qua colour, and who has acquired a vocabulary to match, could respond in such a way as to obstruct immediacy and, therefore, inhibit the Kohler effect. A cybernetic model of colour perception will have to come to terms with the human organism's capacity for silent language in whatever situation we place him. Taylor's model applies directly only to the first beginnings of colour and its constancies, as well as to those artificial situations in which the experimenter's ingenuity can disrupt the ultrastability of the subsystem to which colour belongs.

My second contention arises out of this last point, and is not related to mediacy. In fact, it may seem to be diametrically opposed to that explanation. It is this. Suppose we have a subject who has normal colour vision but who is not interested in colour and has a correspondingly very restricted vocabulary. If he agrees to wear two-colour spectacles over a protracted period, can we predict that the paucity or absence of mediate must result in the manifestation of the Kohler-effect? By no means.

To illustrate my point, let me go back to Stratton. It is impossible, I believe, to find someone who will not, on wearing spectacles which radically distort the spatial ordering of the environment, experience some disruption of equilibrium. Whether the spectacles reverse or invert the field, we will find that we are dealing with a vulnerable subsystem. But a wave-composition distortion (even if three or four-colour lenses were used) does not necessarily affect the equilibrium of the relevant subsystem at all.

...there is no advantage whatever for any animal to be able to see rainbows, or sunsets, or spectral fringes at the edges of objects. He needs to detect the composition of substances at a distance, the pigment qualities of flowers and fruit, of feathers and fur, of rock and earth and vegetation. The "colors" of light as such, of mere illumination, are nothing to him. It is true that the colors of surfaces must be somehow specified in the "colors" of light. One can only see surfaces by means of light. It would follow that an observer cannot distinguish the colors of objects without having the incidental ability to distinguish the "colors" of the spectrum. But it does not follow that sensations of "pure color" are entailed in the seeing of surface color. The sensations⁷ are what I call useless dimensions of sensitivity.

(Gibson, 1968)

I quote from Gibson not because I believe that this is the full story but because it supplements the previous quotation from Taylor. The import of Gibson's comments is that to the extent that colour does not contribute to adaptation, it is a redundant (if not "useless") channel of information. Another way of putting it is that one can find both species (e.g. the cat) and individuals (e.g. most urbanized people) who, if denied the proper use of this channel, will very readily "switch" to non-chromatic cues and, in most cases, will suffer no ill consequences. This is a phenomenon to which I have previously given the name "colour agnosticism".

My conjecture, then, is that if the wearing of two-colour spectacles does not cause disruption of ultrastability, at least two mechanisms, "mediacy" and "colour agnosticism" may be at work. Neither is easy to investigate, but to the student of colour they must surely be of paramount interest.

Much of the discussion which appears in the interpretation of the Howells results (p.139-154) is relevant to the present study. I will not repeat any of the general points made there, but in the Kohler study the problem of establishing, and assessing, new functional equivalence classes was far more complex.

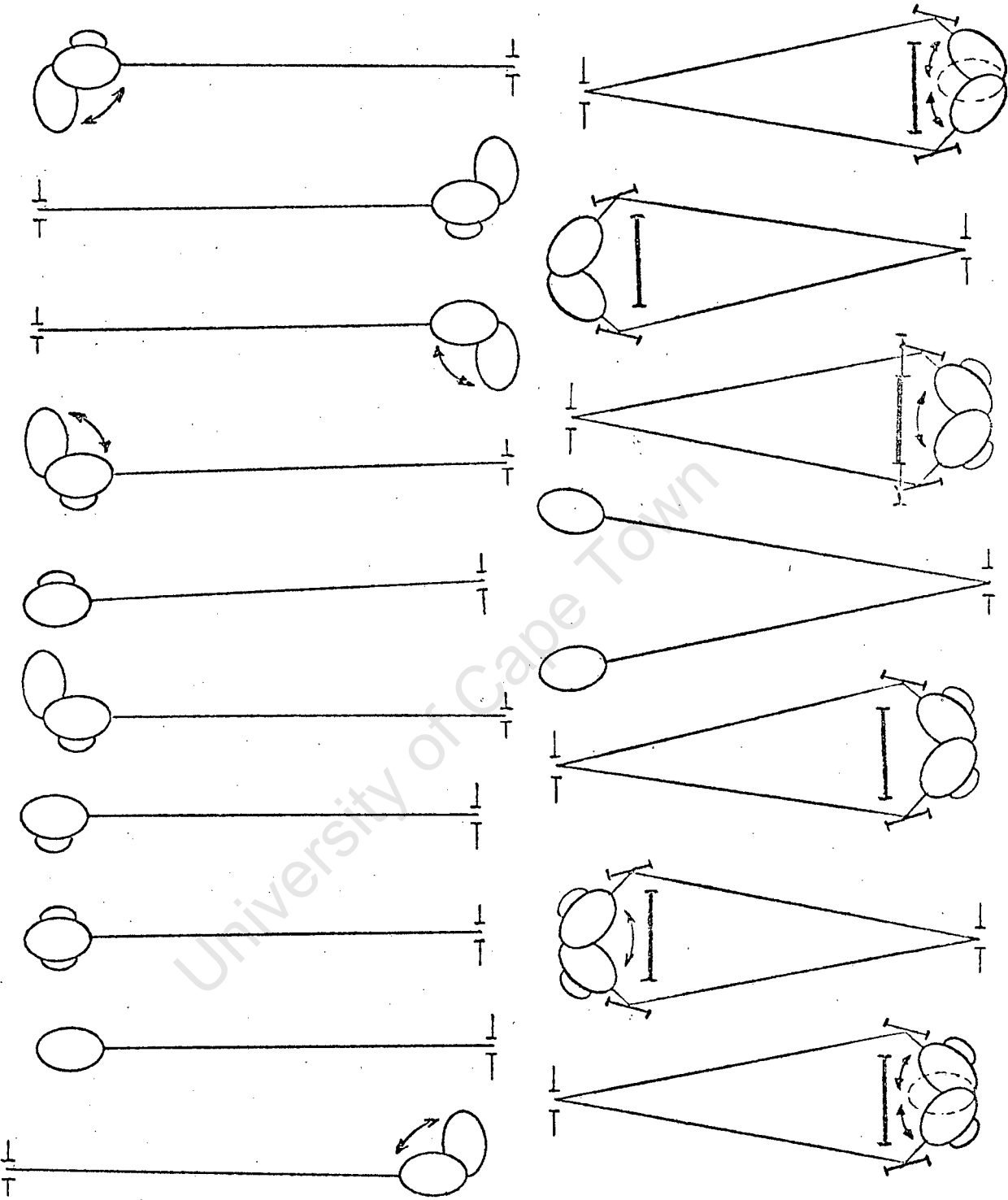
I have already mentioned that the laterality bias in the viewing system and the large intra-subject variability arising out of the method of adjustment used led to the gradual development of different testing conditions involving different modes of regard. This was a most unfortunate circumstance, the implications of which I did not realise at the time. Again, it arose from not taking Taylor's premises seriously and ignoring certain elements of the "total afferent input" to which responses had been conditioned during the experimental sessions. These sessions were all conducted using the viewing system shown in Fig.12, p.186. Now, if it was desired that any new functional equivalence class established should be manifest in a variety of conditions, then the training sessions themselves should have incorporated such variety. To the extent that any element of the original compound afferent input was altered, the preservation of the original equivalence class was jeopardised. I could supply a host of examples. Fig. 19 on p. 223 shows the variety of modes of regard that was actually used during testing. It will be seen that the original viewing situation could have at least the following elements altered:-

- (a) head-movements through 45° instead of 90° as well as 45°
- (b) head inclined with respect to shoulders, but stationary
- (c) mirrors removed and subject seated at an unaccustomed angle with respect to colour-mixer
- (d) head stationary with median plane perpendicular to shoulders
- (e) headphones removed
- (f) headphones retained but tones switched off

Again, this was a valuable lesson which could only be learned "in the field". It meant that any departure from the original viewing conditions introduced an incommensurability as far as Q's colour perception was concerned. If this should seem bizarre to the reader, I can only say that such would have been my own reaction before I embarked on the experiment.

I did not, as in the tone-contingent experiment record Q's experiences and self-reports. I was far too engrossed in the business of trying to elicit the after-effect as such. I cannot, therefore, illustrate Q's reactions in the same verbatim manner. I did, however, take brief notes at various times. In general, Kathryn made almost no mention of any unusual experiences, but in Paula's case, as her first learning curve (see Fig. 13, p.193) approached its asymptote she disclosed that not only was her behaviour becoming more automatic, but

Figure 19



CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: DIFFERENT MODES OF REGARD USED DURING TESTING

it seemed to her that she was able to see something about the match-pairs which actually "looked the same". She used various terms but said that none were really apt descriptions, e.g. "depth", "character", "feature" (but not hue).

Taylor's theory requires, of course, that complete behavioural adaptation should result in match-pairs being perceived as identical in colour. I have already given reasons why this could not be expected to happen under the conditions of the present experiment. An important reason not mentioned is that hue-attenuating goggles were not used or even considered. I have already stated why I believe their use is mandatory if large hue-shifts are to be obtained.

The question of successive contrast deserves some mention here. Just as in the Howells experiment this operated both in the experimental and in the testing sessions, but in the latter its effect was almost nil, at least in the method of single stimuli, since these were not under computer control and there was therefore a much longer interval (about 10 seconds as opposed to 2 seconds) between presentations. I believe this reduced error variance to a significant extent, but as I have argued in the Howells discussion (p.155) it could not have affected the gaze-contingent differences found.

Some discussion concerning the adaptation criterion imposed on the subjects is necessary. At the time I regarded it as a purely arbitrary move to take the product of reaction time and number of errors as the criterion. But on reflection, it has a sound theoretical grounding. In fact, I would say that it adds precision to Taylor's term "readiness". In previous drafts of his book which circulated in our Department he had used the term "response tendency" instead of "response readiness". "Tendency" is a term with obvious drawbacks. It carries connotations of vagueness, of the writer's inability to specify operationally what is intended. "Readiness" is much more direct, but Taylor nowhere defines it. I am here suggesting that, in work with colour at least, "readiness" can be given a strictly designatable construction. Since to be "ready" to make a colour-response means both to give the correct response and to give it quickly, it is a joint function* of reaction time and number of errors. Instead of using the simple product $E \times RT$, however, I would use

*inverse function, more correctly

RT(E + 1). The reason is obvious. Q might ensure that he made no errors by taking an inordinately long time to make his judgement. The formula put forward means that the theoretical limit could never be reached, which is of course as it should be.

Finally, some subsidiary flaws in the design which I have not mentioned before and which I could have eliminated at the time but failed to for one reason or another.

- (1) The nine original source colours were not of the same luminance. This meant that some mismatches could be readily detected by cues unrelated to hue.
- (2) In asking Q to become dark-adapted during the testing sessions, I would direct her attention to the "light-proof" exhaust fan and ask when she could first see a faint grey 'halo' around it. After about five minutes this annulus of light became much more distinct, and I took it as a sign of a reasonable state of dark adaptation. What I did not take into account was the obvious fact that this gave Q a direct clue concerning daylight white which she could use in obtaining her neutral settings and thus vitiate, to a certain extent, the influence of the tones.
- (3) I did not, in the beginning, start a testing session with a few practice trials. Although the effect, if any, is small, there are hazards in starting a subject off without such practice.
- (4) Had I used the white pilot light with both subjects, I could have instituted a method whereby a neutral density filter could be substituted for either of the chromatic filters during a session without warning. This would have added interest to the task and resulted in a higher-amplitude constancy. It would also have constituted an analogue of Taylor and Papert's (1956) experiment on the adaptation to intermittent distortion of the afferent input.

Notes

7. When Gibson banishes the "sensations" as "useless dimensions of sensitivity", the dictum must be understood in the context of his quotation. He is clearly using the term "sensation" in an idiosyncratic way which, if not borne in mind, would confound the sensation/perception issue discussed here (e.g. see p.226-227).

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Chapter 5. Conclusions and Implications

Although the title of this thesis contains the term "transformation" I have not only not defined it, I have hardly even used it thus far.

The definition of "transformation" provided by the Optical Society of America's Committee on Colorimetry (1953) is a "shift of mode of appearance of a color caused by either objective or subjective factors". This clearly attaches a very specific meaning to the term, whereas my own use was derived, in part, from Kohler's (1964) title, "The Formation and Transformation of the Perceptual World". Since I started with a quite distinct framework of reference, however, I need to be more precise. Perhaps I should say what kinds of colour phenomena I excluded from the designation.

Taking a straightforward dictionary definition and applying it to colour, transformation would simply mean some more-or-less definite change in appearance. There are a great variety of ways whereby the appearance of a specific photic stimulus will undergo a change in chromaticness for a given observer. Without giving reasons for the moment, the following phenomena were eliminated:-

Phenomena due to simultaneous contrast (including 'induced' colours)	e.g. Kinney, 1962; Wallach, 1963; Kinney, 1965 a,b; Kinney, 1967.
Adaptation phenomena (including successive contrast, "fatigue", "bleaching" and "minuthesis")	e.g. Helson, 1938; Helson & Jeffers, 1940; Judd, 1940; Cohen, 1946 (review); Jameson & Hurvich, 1951; Siegel, 1965; Scheibner, 1966; Hurvich, Jameson & Cohen, 1968.
Loss of discrimination due to sensory deprivation	e.g. Zubeck, 1969.
Induction of colour by means of non-chromatic stimuli, i.e. "subjective colours"	e.g. Erb & Dallenbach, 1939; Knehr & Lorenz, 1964; Frost, 1965; Cohen & Gordon, 1949 (review); Kinney, 1967; Hepler, 1968; Goranson (1965).
Changes due to disease or trauma (whether resulting in peripheral or central lesions)	e.g. Purdy, 1933; Francois & Verriest, 1957; Verriest, 1963; Kinsbourne & Warrington, 1964; Critchley, 1965; Kinnear, 1966; Lakowski, Haining & Aspinall, 1968.
Changes due to drugs	e.g. Kelly, 1933; Marinesco, 1934; Keeler & Doehne, 1966; Lakowski & Davenport, 1968; Cohen, 1970; Siegel, 1971.
Changes due to direct non-photic agencies (electric current, magnetic fields, etc)	e.g. Kravkov & Galochkina, 1947.

What is absent from this heterogeneous list are changes, or departures from the "veridical", attributed to learning, however conceived. There are a number of such studies, usually subsumed under the rubric, "perceptual learning", of which the following are well-known examples:- Duncker, 1939; Bruner & Postman, 1949; Bruner, Postman & Rodrigues, 1951; Harper, 1953; Baker & Mackintosh, 1955; and Wheeler, 1965. My exclusion of these needs a brief explanation.

A glance at Hebb's model of perception as I have depicted it on p.18 will serve this purpose. Hebb is one of the progenitors of modern psychology's "current of credence" (to use Boring's term) regarding the development and modifiability of perception, and Epstein's (1967) overview could be regarded as a source-book of the kind of research to which it has given rise; McCleary's (1970) collection being another. A fundamental premise on which this large body of theory and experiment has been based is the clearcut distinction between sensation and perception

which we see spelled out in Hebb, and which, as I argued in the first chapter, can be regarded as an amendment (but not more than that) of the Müller-Helmholtz paradigm regarding the psychophysiological substrates that underly experience. The axiomatic basis of the present study (derived from Taylor of course) allows of no such distinction. I might just as logically have chosen the title, "The Experimental Transformation of the Sensation of Colour", but since this may have seemed a question-begging procedure and since I am concerned to understand the nature of colour experience in general, the term perception was preferred.

What I claim to have shown is that the experience of colour, in its most reduced or immediate mode, can be altered (transformed) by procedures which involve the acquisition of new verbal and/or motor responses directed towards compound afferent inputs containing retinal as well as (critical) non-retinal elements. But it became clear to me during the course of this work that there were those who claim to have at their command techniques which would have produced results which were at least as enduring and of greater magnitude than these I have reported. I refer to the induction of colour "hallucinations" and the like by hypnosis, suggestion and direct instruction (e.g. Erickson & Erickson, 1938; Rosenthal & Mele, 1952).

It would have been a simple matter to sweep aside these claims on the ground that they do not fall within the ambit of orthodox experimental psychology. But there were at least three reasons why this move would have been disingenuous:- (a) I have already given at least two instances in which subjects in conditioning experiments have themselves stated that they could not be sure whether the responses they were making were not biased (in favour of the experimental hypothesis) by their knowledge of E's objectives; (b) although the direction and reliability of the alloretinal hue shifts obtained were in accord with the behavioural theory, their quite modest sizes (with a few exceptions) were such that alternative explanations had, at least, to be examined. (c) arising out of the previous points, it could be alleged that subjects had not had their perceptions changed, but rather that their verbal and/or motor responses had been conditioned.

On going through the literature concerned with hypnotic induction of hallucinations in general, and of colour hallucinations in particular, it soon became apparent that fundamental disputes about the very status of the phenomena are still reigning. Against the original claims (with respect to colour) of Erickson & Erickson (1938) and Rosenthal & Mele (1952) were Hibler's (1940), Goldiamond & Malpass's (1961) and Elsea's (1961) negative findings. Moreover, Barber (e.g. Barber, 1959, 1964) has not only discounted the validity of the positive findings, but in papers too numerous to mention has suggested that all the phenomena called "hypnotic" can be elicited by non-hypnotic means (e.g. direct instruction), and that in the case of a visual hallucination, say, the locus of the phenomenon is in any case not sensory or experiential.

My original plan was to mount a full-scale attack on the problem in collaboration with Nevil Doxey (himself a hypnotist and one of the subjects in my Howells experiment), and work has already begun (Doxey & Abramovitz, 1972). But the methodological problems have turned out to be much greater than either of us reckoned with, and I have resigned myself to leaving this particular question mark on my work unresolved. I can, however, make some mention of our design and even of some tentative preliminary findings.

Let a hypnotized Q wear red tinted spectacles and a pair of stereo headphones and while he examines his surroundings let E (the hypnotist) suggest to him that in future whenever he hears a low (260 Hz) tone in his left ear (demonstrated) he will see everything in the same red tint. Similarly, for blue-green spectacles and a high (390 Hz) tone in his right ear. Will Q thereupon exhibit a tone-contingent shift in hue perception on being tested by, say, a method of adjustment?

Before any work was commenced, I formulated two hypotheses:- (a) That compared with his pre-experimental settings, Q's tone-contingent neutral settings would be extremely variable or erratic and would depend largely on the preliminary setting (fixed by E) from which he was required to move, and (b) that on being asked to describe the neutral point so obtained he would use "impossible" terms such as "reddish green" or "green and red all over", or the like.

The second hypothesis was amply confirmed, especially in the case of the first subject, who reported his neutral setting as being "red shot through with green", "red with a green film over it," etc. At that time I felt that this phenomenon by itself was sufficient to refute the notion that the "hallucination" was a genuine experience. It could be more parsimoniously explained, I felt, by appealing to Q's ignorance of the laws of colour mixture and thus providing a report which was "compliant" rather than veracious. But this occurred prior to my knowledge of the report by one of Vogelmann's (1971) subjects (mentioned on p.66) of a very similar phenomenon. However, Silke Vogelmann herself acted as a subject in my tone-contingent study (in full knowledge of the contingencies of the experiment and the characteristics of the colour-mixer); yet she reported, after several experimental sessions, that some of the whites had become "a dirty reddish green"! But that is not all. The second subject (Kathryn) of my gaze-contingent study, reported during the final debriefing that she never saw a neutral grey or white on the colour mixer--she saw a "pinky green". When pressed, she said that the pinks and greens were disposed in "thousands of tiny separate little dots" like a half-tone newspaper photograph.

It was clear that the attribution of "impossible" colours to subjective neutral settings was not by itself a criterion for distinguishing "genuine" from "compliant" self-reports. I recognize, of course, that Kathryn's own description could itself be interpreted as being embarrassing to the behavioural theory, but there are reasons for not feeling alarm on this score:- (a) Kathryn reported that her neutral settings had this appearance prior to the experimental sessions; (b) although she called the colours pink and green, she said that the latter seemed to her to be more blue than green; when she first used the colour mixer she expected her neutral point to be "lilac", and could not reconcile what she actually saw with this expectation; (c) I have since found other individuals who report the neutral point as "half-way between pink and green", or "sort of muddy with pink and green in it", as well as the expected "grey" or "white" which is the term most other people employ. (Virtually all subjects describe the test field as homogeneous, no matter what colour description they provide).

On the question of intra-subject variability, the evidence with the two hypnotized subjects was mixed. In the first case erratic settings did occur, but in the second, Q developed a habit of moving the vernier

dial a small but consistent amount away from her "true" (i.e. pre-experimental) neutral point.

The results, in short, were inconclusive. Taylor's theory is, in principle, general enough to incorporate such phenomena as "hallucinations", "images", etc, and Taylor (1972) has himself begun to articulate a behavioural theory of imagery, but I am not as yet acquainted with its details.

Having accepted that hypnosis and suggestion have not received the attention which they merit in a work on the transformation of colour perception, I shall now proceed to certain important general issues which are raised by my findings in the light of Taylor's paradigm.

The first is this. Why does the transformation of colour perception via non-retinal afferents require so many thousands of trials? If "colour agnosticism" (see p.172) is a not uncommon characteristic in certain individuals it should be possible, surely, to produce a significant change in a matter of a few hundred trials, as Kelly (1933) originally believed. Yet, in terms of "jnd yield", the sheer quantity of conditioning required is quite prodigious, even if, with the aid of the computer, some change is effected in a matter of hours. The answer, I believe, is implicit in previous discussions on the difference between colour in the illumination mode and colour in the object mode. As the first thought experiment (p.35) indicated, and as the quotations from Taylor (p.219) and Gibson (p.221) imply, a universe in which chromatic changes occurred only in the illumination mode would be colourless! A universe which featured colour equally in the object and the illumination modes would produce in us a kind of agnosticism that would require relatively little effort for transformation to be effected. But our universe is one in which colour is almost invariably experienced in the object mode. We have, according to Taylor (see p.32), developed very complex sets of readiness towards the variety of chromatic stimuli in our environment precisely because we were, in our formative years, interested in objects, not colours. So that, although the passive wearing of bi-coloured spectacles for five months (e.g. Harrington, 1965) may not cause any disturbance or after-effect in a given subject, we might find that a concerted attempt by an outsider to elicit a new kind of readiness, as in the computer-controlled puzzle environment (p.185f.), is fiercely resisted,

even though the colours are presented in the illuminant or aperture mode. Harrington's subject showed that colour as an information channel is largely redundant—provided other channels are left open. But once these are barred, it re-asserts its primacy: it will not be "gate-crashed".

This is probably one of the reasons why colour has been such a perennial source of puzzlement and dissension in epistemology. Dr. Johnson could refute Berkeley by kicking a boulder; he was, as it were, verifying his retinal impressions with tactile and kinaesthetic ones. But how could he have verified, via another modality, or via a specific behaviour, that the stone was brown, and not grey? It takes an imaginative leap like Taylor's to question the primordial nature of colour. We do not, in mature experience, have occasion to doubt that colour is one of the unanalysable givens of experience. But when my subjects (unwittingly parodying William James) complained that they could not see the colours because they made so many errors (see p.101), colour begins to become understandable as readiness. It is, of course, only one of a very large family of sets of response-readiness. The subsystem to which colour belongs does indeed have strange properties, and only a cybernetic model, so I believe, is likely to elucidate the lines of relationship with the rest of the multistable family. But we do not have to wait for the complete unfolding of such a model in order to realise that most philosophers have been trammelled by the experienced immediacy of colour. Two or three examples will suffice to show how a new mode of conceiving colour would open up different vistas for the philosopher.

Smart (1961) arguing convincingly against both a subjectivist and an objectivist view of colour gives us his own solution to the riddle I posed for Dr. Johnson. For Smart the solution to "verifying" the colour of an object seems to come close to a behavioural point of view: "visual experiences themselves matter not at all: provided that the discriminatory reactions are right, the experiences can be what they please". To drive his point home, he asks us to imagine

...a race of congenitally blind people who have as slaves a race of normal percipients. There is a system of taboo whereby the slaves must never use colour words, so that they never themselves utter them nor understand them if uttered by others. The blind people cut up wool into hundreds of pieces and dip different bits of wool into various

dyes. (One dye to each bit of wool but many bits of wool to each dye.) They then do experiments on the slaves and discover their discrimination patterns with respect to the bits of wool. We can suppose each piece of wool to be tagged in some way unknown to the slaves, and that the slaves assort the pieces of wool into various heaps, the pieces are then shuffled up together again, and it is found that when the pieces of wool are sorted out by the slaves again the same pieces as before go into the same heaps. The slaves can distinguish bits of wool from different heaps but not bits of wool from the same heap. More refined experiments giving the slaves more time, better light, etc., would of course lead not to a small set of heaps but to a very large number of heaps giving the idea of a colour continuum: the blind men would say that the colour of bit of wool B is between the colours of bits of wool A and C, if a slave can distinguish A from C, but not A from B or B from C.

(Smart, 1961, p.140)

Let us overlook the fact that a congenitally blind person would not be able to start such an experiment because the concept of a dye is one which he would presumably only begin to comprehend after he was able to observe the kinds of discriminations made by his slaves. Smart is on the right road in the sense that the blind man, on Taylor's principles, will see colours to the extent that his readiness to select one piece of wool rather than another, or to give a given piece of wool one label rather than another, is as quick and as accurate as a sighted person's. But for this to happen the "mediates" must drop out (see p.219). As long as their "knowledge" of the colour continuum is mediated by making tallies of which bits of wool went into which heap, it is very far removed indeed from colour as experience, even though it is not false knowledge. As a thought experiment it does not go far enough. The mediates (wool gathering!) are so cumbersome that it is inconceivable that the blind rulers could ever develop the exquisite degree of readiness whereby we immediately perceive this colour as red and that as blue.

But Smart's blind rulers would face another problem, even if they conquered the problem of mediacy. How would they comprehend the phenomena of colour constancy, without which no-one could claim to be acquainted with colour in any meaningful sense? Perception is not equivalent to mere discrimination. Until Smart realises that behaviourism, in the hands of Taylor, is a radically different enterprise from

the behaviourism practised in the animal laboratories of most psychology departments he will not have an answer to either the subjectivist or the objectivist approach to colour, even though he can refute them both.

Armstrong (1969) accepts a "Direct Realist" as well as a "Reductivist" account of the nature of colour, which he calls "Scientific Realism". A "Colour Realist", Armstrong tells us, is "one who holds that the colour of the surface of an object, or the colour of an object as a whole, exists independently of its being perceived". A Direct Realist maintains that "in at least some cases, perception gives us a direct, that is, non-inferential, awareness of the nature of physical phenomena". In addition "a Reductivist...holds that the colour of the surface is nothing but the light waves emitted from that surface or something of that sort".

Armstrong puts the case for Scientific Realism quite vividly.

If a surface looks red, and is emitting light-waves of a sort or sorts characteristic of red surfaces, it is red. If it looks red, but is not emitting such a sort or sorts of light-waves, it only looks red.

We are asked to imagine Dr. Johnson, armed with a spectrophotometer laboriously plotting the spectral reflectance curve for the rock (under a standard illuminant) and when it is apparent from this evidence that it is not grey, triumphantly proclaiming, "I refute it thus, Sir!"

This bit of absurdity is mentioned, not to make fun of a philosopher but to bring out the difference between Taylor's brand of emergent materialism and a naive physicalism which stems from a misapprehension of Newton's achievement in correlating spectral hues with "refrangibilities". For Taylor, the human machine is far superior to any spectrophotometer in terms of multiple simultaneous response-readiness.

...the subjective report is much more reliable than any objective measurements can ever be because it results from an incomparably more sophisticated statistical operation than any that can be applied to the objective data... perceptual experience is a sensitive instrument that reveals the state of the system [organism-and-environment] as a whole.

(Taylor, 1972a)

To understand how colour emerges as an aspect of an organism-environment interaction, we need have no knowledge whatever of wavelengths. Knowledge of wavelengths may help us in all sort of ways, but man experienced colour for millennia before Newton. Our problem is to understand the mechanism that has made this possible. Armstrong presumably believes that his is an extremely avant-garde exposition of the nature of colour. I believe that he is actually putting the clock back. Instead of concentrating on the intricate, complex, dynamic system that is man-in-his-environment, he fastens on a particular device in physics. This device (the Newtonian paradigm) is, we are told, what colour is all about. Before that, the man-in-the-street's knowledge of colour was presumably illusory. But how did Newton himself make his discovery if he himself did not have this (also illusory?) ability to experience the hues of the spectrum?

Campbell (1969) demarcates his problem very succinctly by pointing to the "notorious triad of inconsistent propositions",

Colours are properties of what is seen.
 What is seen is a physical object.
 Colours are not physical, observer-independent, properties.
 (Campbell, 1969)

His solution is simply

to identify having colour impressions with
 having a nervous system in a suitable state...
 Where colour quality is concerned, it is the
 actual condition of the various retinal regions
 that counts. That a given region has a dis-
 tinctive four-fold output is the information
 the brain receives when we have colour-quality
 impressions.

(Campbell, 1969)

We are back, in other words, to a physiological transducer-decoder model (see p.14 and p.37).

It cannot be emphasized too often that Taylor does not deny that colour can be studied from the point of view of behaviourism (cf. Smart) physics (cf. Armstrong) or neurophysiology (cf. Campbell). When Taylor

says that he wants to put the "psyche" back into psychology he means it quite seriously. But in order to study "the phenomena of conscious experience" we need a paradigm that will be superordinate to those which serve each of these disciplines—including S-R behaviourism itself.

How would Campbell apply his neurological model to, say, my subject Paula (p.209), who saw the same objective stimulus as having one colour when her head was turned to the left and as having another colour when her head was turned to the right? The critical proprioceptive afferents are in this case related to muscle tensions in the neck. But they could, in principle, have been almost anywhere. The neurophysiologist might be able to tell us, post hoc, what substrate phenomena underlay these behavioural and experiential events, but as an explanatory model it would be trivial.

The transducer-decoder model is inadequate because it pays insufficient attention to the complexity and plasticity of the multi-stable system. That system has to be studied as a dynamic whole, the preferred experimental technique involving a deliberate and controlled disturbance of one or more of its parts. We cannot do without postulating substrate neural events, but they follow rather than precede what we can find out about the total functioning system through observation as well as through asking the subject to describe his experiences.

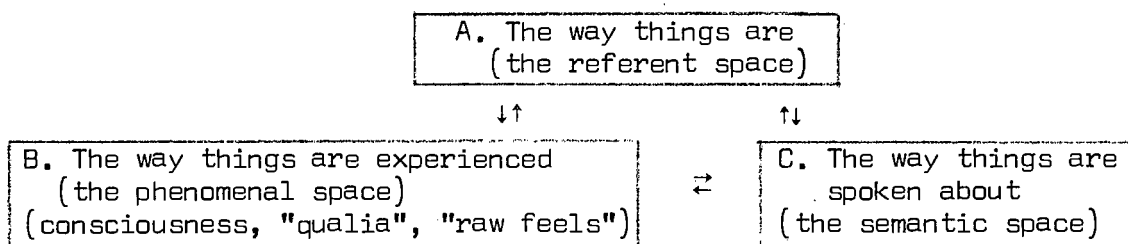
This leads us naturally to the hotly-debated issue concerning the relation between language and colour. Wittgenstein's probable answer to Dr. Johnson's dilemma can be gauged from this quotation (in Landar et al, 1960):-

Wie erkenne ich, dass diese Farbe Rot ist?—Eine Antwort wäre: 'Ich habe Deutsch gelernt.' (Ludwig Wittgenstein Philosophische Untersuchungen §381.)

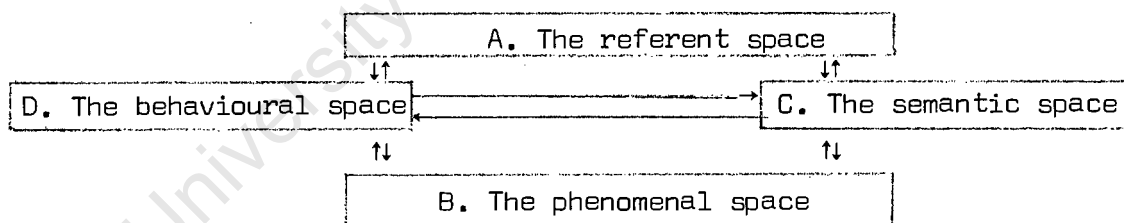
The verification of immediacy, Wittgenstein's quip suggests, is one of language's primary functions. But a moment's reflection raises doubts and suggests qualifications. Suppose Wittgenstein had written:-

How do I know that this note is C Sharp? An answer would be: "I have learned to speak English."

We see from this that immediacy and language have no invariant correspondence across modalities: that is, we don't learn to label the pitch continuum at our mother's knee in the way that we do the hue continuum. This in turn suggests that the "qualia" or "raw feels" of experience are precisely what Wittgenstein was hoping to bracket out of the triangle.



Let us try to establish where, axiomatically, Taylor stands. For him, B encompasses the traditional concerns of psychology, the neglect of which since Watson, he has never ceased to deplore. One function of C is to serve as pointer-readings for B, but psychology cannot manage with this triad: we need to insert D, the way things are responded to (the behavioural space), between A and B; which gives us:-



The complexities have grown; the role of C, in Taylor's axioms, being apparently a dual one. (I say "apparently" because he has never spelled out this facet of his system.) C not only serves as pointer readings for B (in which case it is the dependent variable), it can also operate in a way which is co-equal to D (in which case it is the independent variable), so that we have

$$B = f(A, D, C)$$

and $C = f(B).$

If we bracket out C, Taylor's philosophical pre-suppositions can be more easily delineated. A and D belong to the physical order (the multistable system of organism-in-environment). B belongs to the

phenomenal order (consciousness or "multiple simultaneous readiness") which is an emergent function of A-and-D. On the provisional assumption that the realm, in Taylor's axioms, to which C is assigned is problematical, let us examine some lines of current research concerning the relation between language and colour and relate them, if possible, to Taylor's concepts of colour in general, and the findings I have reported in particular.

There are before me some twenty references* which, in one way or another, bear on this problem. The first impact on going through them is the variety of disciplines they represent: language & cognition, information theory, colour science, anthropology, social psychology and developmental psychology (to assign them into their broadest categories). The next thing that strikes one is that literally none of them is incorporated into a general psychological theory of colour perception. In saying this, I am not implying that psychological aspects of colour perception have been ignored: indeed, we have a variety of sources to draw upon, from the phenomenological treatise of Katz (1935), to general treatises in which the topic features as a separate section (e.g. Evans, 1948, Optical Society of America, 1953). What we do not appear to have is a unified and general psychological orientation, with a reasonably defined axiomatic basis, which will enable us to embrace and consolidate the diverse and sometimes contradictory findings that emerge from the cited research on language and colour.

If we look into the matter more closely, we find that many workers (of whom Lenneberg is probably the most distinguished) have exploited the field not because they are interested in the general problem of colour perception as such, but because the colour referent space happens to be so neatly and completely specifiable:-

...since the input to at least some conceptualization processes is the sensory perception of things, there is, of course, also a relationship between words and objects. This relationship may be studied empirically, under laboratory conditions. For this purpose, it is desirable to choose words that have simple referents, in the sense that they can be exhaustively described by objective measurement of all of their physical properties. This condition is fulfilled in only a small class of words, namely those that describe the sensation of certain physical properties themselves... Our aim is to study how words relate to

* Helsey & Chapanis (1951); Ray (1953); Brown & Lenneberg (1954); Conklin (1955); Whorf (1956); Chapanis & Halsey (1955); Lenneberg (1957); Brown (1953); Berko & Brown (1960); Lender et al. (1960); Lenneberg (1961); Klein (1964); Chapanis (1965); Ponzo (1965); Sternheim & Boynton (1966); Lenneberg (1967); Kopp (1967); Greenfield & Bruner (1969); Keasey et al. (1969); Chapanis & Overtey (1971); Heider (1972).

objects. But we cannot study the behavior of words unless we keep some control over the objects...

We must do everything we can so as to bring some order into physical "reality". We have chosen phenomena that can be measured and ordered with respect to each other. The color space is simply an ordering device that allows us to assign every possible color a specific position or point. The entire world of color is encompassed in the color space.

(Lenneberg, 1967, p.337-339)

Lenneberg is here interested in "the language of experience" in its most general aspect; that he has chosen the colour space as his paradigm for physical "reality" is a fact of great significance, but he himself does not seem to be aware of it. He mentions that one might have used, say, the intensity and frequency scale of pure tones, or the centigrade scale for temperature. And indeed there is nothing a priori to exclude from such research the referent spaces corresponding to taste, smell, the cutaneous and kinaesthetic senses, and so on. He does not, as far as I can determine, give any reason for choosing the colour space other than that it happens to be so convenient for purposes of laboratory experimentation.

For Taylor, however, it is a matter of fundamental psychological importance to establish just why it is that we do not learn to map the acoustic space in as articulated a way as we do the colour space. It is no answer to say that pitch, say, is perceived along an ordinal or quantitative continuum, whereas hue is perceived along a qualitative continuum: this simply begs the question. Why do we experience these modalities in such fundamentally different ways? Questions such as these belong, of course, to the phenomenal realm, which is usually nudged out by most current investigators. The tacit presupposition, presumably, is that the Müller-Helmholtz-Hebb paradigm (see p.18) takes care of such contingencies. Sensation is the raw material of experience: what we learn at our mother's knee is simply to tag this or that sensation in some culturally-determined fashion. But we cannot get beyond sense data: we have to accept them as elemental.

In a sense the Whorfian hypothesis, in its strong form at least, posed a threat to this axiom, and much of the research on comparative colour categorising derives from Whorf's (1956) original questions

regarding "linguistic relativity". That the Whorfian hypothesis has not been sustained, except in a very diluted form, and hedged with numerous qualifications and caveats, is testified by the work of, for example, Brown and Lenneberg (1954), Lenneberg (1957, 1961, 1967), Brown (1958), and Ponzo (1966). In a recent paper, moreover, Eleanor Heider (1972) has delivered what she believes to be the final death-blow to any lingering remnants of this tradition. I shall return in a moment to Heider's concept of colour "universals". What needs emphasizing here is that although there may be family quarrels about the relation between colour and language, ranks would immediately be closed were it suggested that the "primitive core of consciousness" itself has to be acquired by the process through which the multistable system—organism in environment—achieves stability; or that sense-data can be interpreted as "mediated events reflecting the history of the subject's interaction with his environment" (Taylor, 1962, p.341).

Rarely, if ever, in these debates, do we find much thought expended on the behaviour of the infant and young child and his colour ecology. If we recall Taylor's hypothesis that the experience of colour springs from the child's growing ability to respond differentially to objects of differing spectral reflectances—but for reasons other than these wave-composition differentials, it becomes clear why he should start by looking at those aspects of the child's material environment which can be categorized as edible or non-edible. We should resist the temptation to smile at the homeliness of this conjecture. In fact, I should like to suggest that we can go even further than this. The very detailed observations and experiments by Spitz (1965) show that a primitive kind of selecting/rejecting mechanism exists virtually from birth. Taylor may have been perfectly correct in maintaining that choice through reaching responses is not possible until about six months, but if we think of the mouth as an effector, we have the possibility that a more primitive set of response-readinesses can begin to mediate a crude type of colour perception (I say "crude", because it will, initially at least, lack the constancies which, in maturity, we take so much for granted). This notion is supported by Erikson's (1968) developmental schema. Like Taylor, he puts the critical period for the development of "autonomy" ("to hold on/to let go") as coinciding with the young child's developing musculature (12-36 months) and like Taylor, he regards this period as crucial for the development of "freedom of choice". But, like Spitz, Erikson does not exclude some forms of instrumental behaviour from the first year of life.

The import of this discussion will perhaps become clearer if we return to Heider's concept of "focal colours". She cites evidence (1972) which, she claims, supports the hypothesis that "there are salient areas of the colour space (... 'focal colours') which are universally the most linguistically 'codable' and the most easily remembered", even by speakers (the Dani of New Guinea) whose vocabulary contains no hue names at all. I do not propose to debate whether her findings "challenge", as she puts it, "linguistically causal interpretations of earlier language-cognition studies using color". What I regard as significant in her paper is that, having satisfied herself that the "language-cognition hypothesis" has to be abandoned, she concludes that her four focal colours red, yellow, green and blue are most probably a function of the physiologically primary hues of primate vision (De Valois and Jacobs, 1968) and that "the colour space would seem to be a prime example of the influence of underlying perceptual-cognitive factors on the formation and reference of linguistic categories". We are back, in other words, to the M-H-H paradigm, and Whorf is stood on his head.

Heider, I believe, has been the victim of a very common source of confusion among psychologists. It may certainly be the case that these four colours are "physiologically primary" in the sense that the retinal-neural apparatus can best be understood in terms of a corresponding differential "tuning" mechanism. It does not follow however that simple exposure to these hues results in immediate experience of them. Although the evidence in the present study was obtained from placing adults, not infants, in certain critical situations, transformation of colour perception was shown (see p.204) not to occur when O merely inspected certain colours to left and to right through different filters; yet a gaze-contingent shift did occur with the same colours over the same period of time when O attempted to direct a singular response to a given source-colour whether it was seen through the left or the right filter. We can accept that this kind of evidence does not conclusively prove that a similar mechanism operates in childhood (cf. Wohlwill, 1966, p.202), but I am concerned here with axioms rather than specific mechanisms; with persuasion rather than demonstration.

But the argument does not rest with positing, as Heider does, a correspondence between focal colour experiences and the physiological primaries. We must, as I said, examine the colour ecology of the infant

and young child. I know of very little detailed cross cultural research into this question, but we do not need to look very far afield to discover ecological hue universals (but in which saturation and lightness show considerable variability):- e.g. the redness of mucous membrane, tongue, gums, palms, etc; the yellowness of teeth, sclera ("white of the eye"), milk, cream, etc; the greenness of vegetable matter, mucous, etc; the blueness of the sky. It is unlikely that colour evolved (in any species) unless life depended on it (initially at any rate); and it would be quite extraordinary if the biological apparatus developed were not finely tuned to environmental exigencies. What we must not be beguiled into thinking, however, is that this kind of correspondence is both necessary and sufficient for the experience of colour. The reader is referred again to the first thought experiment (p.35) which shows, quite crucially I think, how the M-H-H axioms differ from those of Taylor's. For Heider's sake, I will make the conditions of the experiment even more stringent. Let a normal neonate be reared in an environment in which what we call red, yellow, green and blue are available at their most saturated—but only in the illumination mode. Would she still expect such an individual to experience "color universals"?

We may sum up Taylor's potential contribution to the colour/language/cognition debate by paraphrasing what has already been said (p.219) on the role of mediate in the development of perception. Colour experience, in its most basic mode, is a form of cognizing in which the mediate have dropped out of consciousness. Language serves to refine this im-mediate cognition by narrowing the range of equivalence classes that are established through interaction with the environment, and multiplying their number. Beyond this point, Taylor does not venture.

This thesis began with an examination of the "axioms for a science of colour", and it may be appropriate to end on the same theme. Proximity is not called for. The reader is invited to examine again some of the "basic facts and concepts of color science" as formulated by Burnham et al. (1963) (p.20) in the light of the evidence I have presented in the third and fourth chapters and the arguments that I have adduced throughout the thesis. To the quotations I listed then I should like to add another two which are used as chapter headings in that "primer":-

The color response in the normal observer can be affected by: energy variations in the color stimulus, spatial and temporal relationships within the stimulus field, the areas of the retina stimulated, the state of the observer's visual mechanism, and the observer's mental attitude.

(Emphasis added)

(p.53)

When a color stimulus acts on the color receptors, what happens in the receptors and their attached nerves is so poorly understood that it is only possible to speculate about how color responses are produced.

(Emphasis added)

(Burnham et al., 1963)

(p.179)

Confessions of ignorance are, of course, a virtue not a vice, and Burnham and his collaborators can certainly not be accused of hiding skeletons in the "color science" cupboard. We have a long way to go before a true science of colour can emerge, but a comment on each of these admissions cannot be withheld:-

(1) The fact that tacked on to the list of physically and physiologically identifiable independent variables we find the lame "and the observer's mental attitude" can mean only one thing. Taylor (1968) was not exaggerating when he claimed that modern psychology was dominated (and undermined) by two conflicting sets of axioms, the Müller-Helmholtz-Hebb axioms and the mind-over-body (m-o-b) axioms.

(2) The fact that physiological transducer-decoder theories of colour rest on such slender and hotly-contested ground should surely give the disputants pause to reflect on the possibility that they have started at the wrong end of the logical hierarchy. If acoustic and neck-muscle afferents can, as I believe I have demonstrated, have an effect on "the mode of appearance of color that is the least removed from pure sensation" (Burnham et al., 1963, p.51), surely it is time to consider putting down the old tools and looking around for new ones.

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University of Cape Town

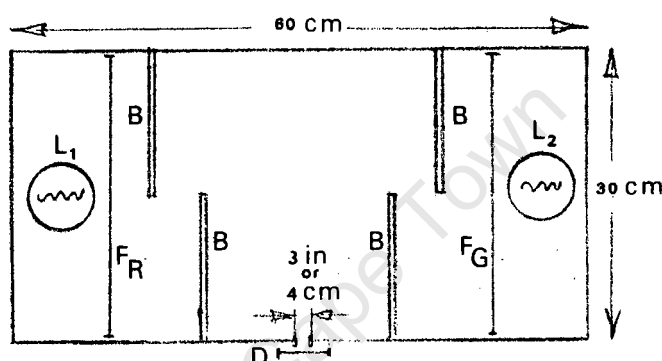
(P.T.O)

## Appendix 1

DESCRIPTION OF COLOUR-MIXERS

- A. Two-colour mixer, used during experimental and testing sessions for tone-contingent study (Chapter 3), and during testing sessions for gaze-contingent study (Chapter 4).

A diagram (in plan) of the mixer-box is shown below.



$L_1, L_2$  = 220v, 150w Philips Photocrescenta enlarger-type tungsten lamps (PF 605 E/51)

$F_R$  = Red Filter, Cinemoid No. 12 (Deep Rose)

$F_G$  = Blue-Green Filter, Cinemoid Nos. 62 (Turquoise), 3 (Straw) and 50 (Pale Yellow), in series.

(For filter characteristics see Appendix 3, p.253.)

$B$  = Baffles, disposed (by trial-and-error) in such a way that the rear of the mixer (lined with white blotting paper) was homogeneously illuminated.

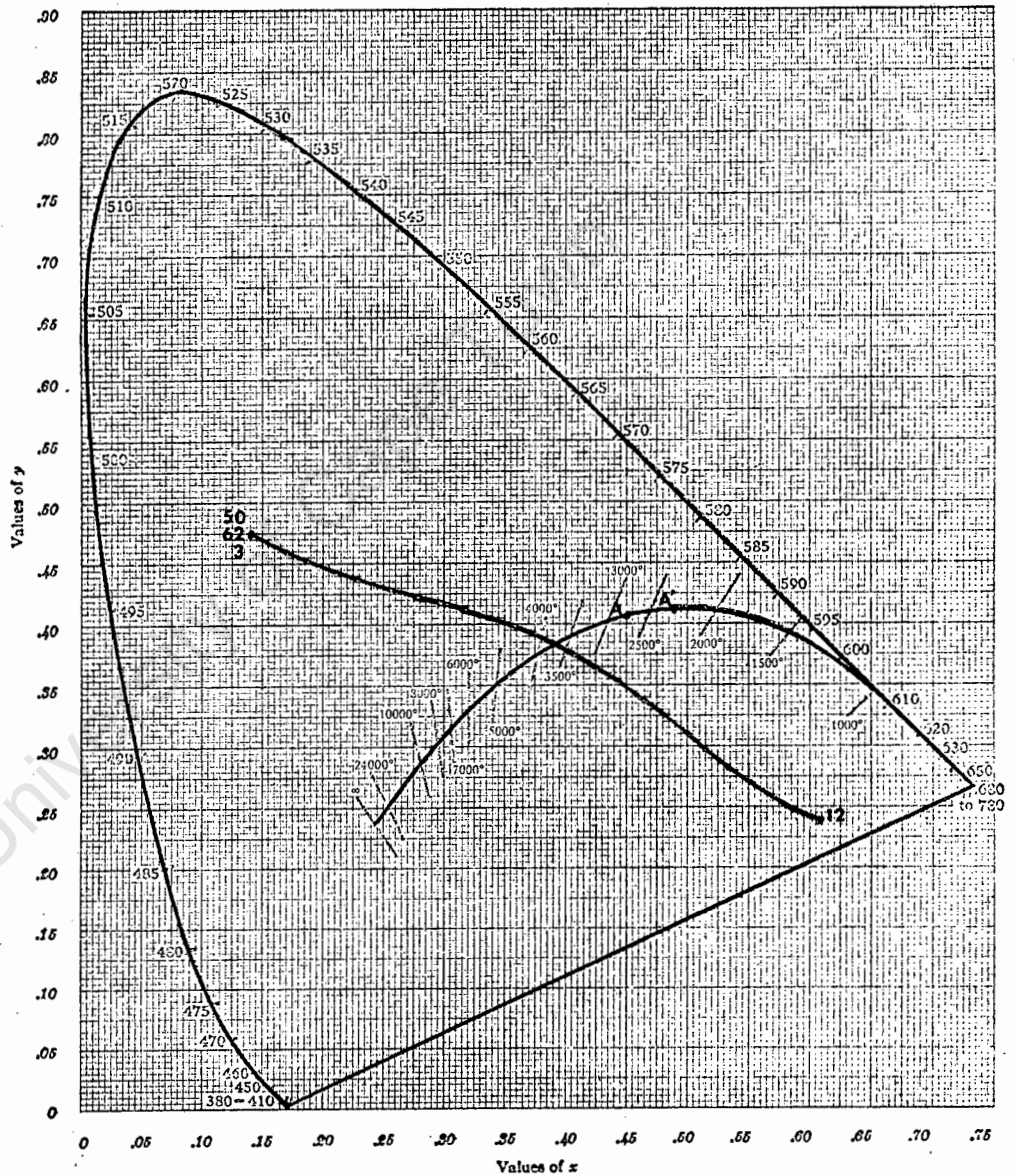
$D$  = light-scattering Kodak flashed-density filter (0.4)

The interior of the mixer was painted matte-black.

The control box contained two electronic dimmer circuits using tri-ac semiconductors. Each circuit was independently wired to  $L_1$  &  $L_2$  respectively and to a dual 500K potentiometer in such a way that revolution of the shaft decreased the voltage across  $L_1$  as it increased that across  $L_2$ , and vice versa. A vernier dial was fitted to the potentiometer shaft. Readings could be made to two decimal places on the arbitrary scale 0-100 (BG-R). The control knob required  $5 \times 360^\circ$  revolutions to produce  $1 \times 180^\circ$  revolution in the potentiometer shaft, i.e. it was geared 10 to 1. The 0-100 continuum did not cover the total range of maximum saturated BG to maximum saturated R. In order to obtain maximum saturations of each colour the dimmer circuit was bypassed and either  $L_1$  or  $L_2$  on their own were switched in. At a setting of 50.0 (author's own approximate subjective neutral point), the voltages across  $L_1$  &  $L_2$  were 86.0 & 105.0 respectively.



**Chromaticities:** The chromaticity co-ordinates of the saturated colours obtained using the lamps and the filters mentioned above were approximately as follows. Red:  $x = .62$ ,  $y = .24$ ; Blue-Green:  $x = .14$ ,  $y = .47$ . These co-ordinates are shown in the diagram below. A represents the co-ordinates for each lamp at its full rated voltage. A' represents the co-ordinates of the two lamps at the approximate achromatic point (operating at less than half the rated voltage). The locus of the transition from saturated red to saturated blue-green is shown by a best-estimate curve.



**Luminances:** These were measured on a Hagner Universal Photometer which automatically takes into account the observer's luminosity function. As this instrument was not sensitive enough to record the luminances measured from the observer's position, readings were taken at the aperture of the colour-mixer (using the 3° mask) and are shown after the appropriate correction factor (.09) was applied. For the tone-contingent study the (corrected) readings obtained were all approximately .36 cd/m<sup>2</sup>. For the gaze-contingent study the corresponding figure was .18 cd/m<sup>2</sup>.

A digitizer was constructed consisting of series-parallel resistances which switched in appropriate voltages across  $L_1$  and  $L_2$  so as to produce 16 settings between vernier scale readings 26.0 and 71.0, calibrated in steps of 3.0 vernier units.

- B. Three-colour mixer, used during experimental sessions (and some testing sessions involving simple comparisons for the first subject) in the gaze-contingent study (Chapter 4).

Instead of using 220v lamps, three miniature 24v lamps were used, the filters covering them being Cinemoid nos. 5 (Orange), 21 (Pea Green) & 42 (Pale Violet). (See Appendix 3, p.253 for filter characteristics).

A separate digitizer allowed different voltages of any two of these lamps to be switched in. Of the 24 possible combinations, nine were used, to which the following descriptions were applied (by the author).

| <u>Colour No.</u> | <u>Digitized Setting</u> | <u>Description</u> | <u>Luminance</u><br>(cd / m <sup>2</sup> ) * |
|-------------------|--------------------------|--------------------|----------------------------------------------|
| 1                 | 1 - 0                    | Orange             | 9.4                                          |
| 2                 | 1 - 2                    | Desaturated Orange | 4.5                                          |
| 3                 | 1 - 4                    | Pink               | 3.4                                          |
| 4                 | 2 - 0                    | Lilac              | 6.3                                          |
| 5                 | 2 - 2                    | Lilac-Grey         | 3.9                                          |
| 6                 | 2 - 4                    | Pale Green         | 4.5                                          |
| 7                 | 3 - 3                    | Chrome Yellow      | 4.5                                          |
| 8                 | 3 - 5                    | Lime Green         | 4.9                                          |
| 9                 | 3 - 7                    | Light Bright Green | 9.9                                          |

\* readings taken at aperture of colour-mixer and corrected as indicated on p. 246a.

## Appendix 2

### CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: FORTRAN PROGRAMME LISTINGS

```

0001  FTV,R
0002  PROGRAM PHDH
0003  DIMENSION  IFARL(18,2),IRONG(18,2),ILATR(18,2),SUM(18,2)
0004  DIMENSION  SOS(18,2),IRAN(600),IFEV(200),IDATE(10),NAME(6)
0005  DIMENSION  VMMRS(18,2)
0006  COMMON  ITIMT,ITIMC,ITIME,ITIMP,ITIMS,IERR1,IERR2,IERR3,
0007  1  ISTIM,IFREV,IOPS,IENV,IENR,IEPV,IEPR,IFERF,
0008  2  ILATE,VERV,VERVR,VERPV,VERPR,ITIMW,ITIME
0009  C
0010  NEXT = 1
0011  500  WRITE (2,10)
0012  10  FORMAT (/,"ABRAMOVITZ - PHD.H",/)
0013  WRITE (2,11)
0014  11  FORMAT (/,"DATE : ")
0015  READ (1,12) (IDATE(I),I=1,10)
0016  12  FORMAT (10A2)
0017  WRITE (2,40)
0018  40  FORMAT (/,"TAPE(1) OR TTY(2) : ")
0019  READ (1,*) I
0020  GO TO (92,93),I
0021  92  READ (5,*) (NAME(I),I=1,6)
0022  READ (5,*) IRLCT,IRLCV,ISESV
0023  READ (5,*) ITIMT,ITIMC,ITIME,ITIMP,ITIMS,ITIMW
0024  READ (5,*) IFEED,INEGV,INEGR,IPOSV,IPOSR,INEGP
0025  READ (5,*) ALOW,AMID,HIGH
0026  READ (5,*) IFPAY
0027  GO TO (94,95),IFPAY
0028  95  READ (5,*) IBFWD,IBASE,IERP,ISPD
0029  READ (5,*) AVER,SDEV
0030  94  CONTINUE
0031  GO TO 90
0032  93  WRITE (2,13)
0033  13  FORMAT (/,"SUBJECT : ")
0034  READ (1,12) (NAME(I),I=1,6)
0035  WRITE (2,14)
0036  14  FORMAT (/,"ELOC ELOCN SESSN")
0037  READ (1,*) IRLCT,IRLCV,ISESV
0038  WRITE (2,15)
0039  15  FORMAT (/,"TIMT TIMEC TIMEF TIMEP TIMES TIMEW")
0040  READ (1,*) ITIMT,ITIMC,ITIME,ITIMP,ITIMS,ITIMW
0041  WRITE (2,16)
0042  16  FORMAT (/,"FEED PVEGV PVEGR PPOSV PPOSR +OR-F")
0043  READ (1,*) IFEED,INEGV,INEGR,IPOSV,IPOSR,INEGP
0044  WRITE (2,17)
0045  17  FORMAT (/,"DIGITIZER LIMITS : L,M,H : ")
0046  READ (1,*) ALOW,AMID,HIGH
0047  WRITE (2,18)
0048  18  FORMAT (/,"PAYOFFS - VC(1), YES(2) : ")
0049  READ (1,*) IFPAY
0050  GO TO (90,91),IFPAY
0051  91  WRITE (2,21)
0052  21  FORMAT ("1/2WD BASIC ERROR SPEED")
0053  READ (1,*) IBFWD,IBASE,IERP,ISPD
0054  WRITE (2,22)
0055  22  FORMAT ("4FAN & SDEV SPECS : ")
0056  READ (1,*) AVER,SDEV
0057  90  WRITE (2,19)
0058  19  FORMAT (/,"STARTING TRIAL NUMBER : ")
0059  READ (1,*) NTHL

```

```

0060      GO TO (510,520),VEXT
0061      C
0062      510      J = 1
0063              DO 100 I = 1,IBLCV
0064              K = I*IBLCT
0065              READ (5,20) (IRAV(L),L=J,K)
0066      20      FORMAT (25I3)
0067              J = K+1
0068      100      CONTINUE
0069              J = IBLCV/IBLCT
0070              I = J*IBLCT
0071              IF (IBLCV - I) 87,87,88
0072      88      J = J+1
0073      87      K = 1
0074              DO 89 I = 1,J
0075              L = I*IBLCT
0076              IF (IBLCV - L) 86,85,85
0077      86      L = IBLCV
0078      85      READ (5,20) (IREV(V),V=K,L)
0079              K = L+1
0080      89      CONTINUE
0081              VEXT = 2
0082      C
0083      520      DO 110 I = 1,2
0084              DO 110 J = 1,13
0085              IEARL(J,I) = 0
0086              IROVG(J,I) = 0
0087              ILATR(J,I) = 0
0088              NUMRS(J,I) = 0
0089              SUM(J,I) = 0.
0090              SQS(J,I) = 0.
0091      110      CONTINUE
0092      C
0093              IVIT = VTRL
0094              VTRL = VTRL - 1
0095              JENR = 0
0096              VERNV = 1
0097              VERNR = 1
0098              VERPV = 1
0099              VERPR = 1
0100              ICNT = 0
0101              VER = 0
0102              SUME = 0.
0103              RSUM = 0.
0104              BSQS = 0.
0105              IBER = 0
0106              IPAYA = 0
0107              IEARN = IRASE
0108              DIUR = VEFED*IBLCT
0109              WRITE (2,25)
0110      25      FORMAT (777)
0111              PAUSE
0112      C
0113      C
0114      530      DO 200 I = 1,IBLCV
0115              DO 100 J = 1,IBLCT
0116      C
0117              K = (I-1)*IBLCT + J
0118              ISTIM = IRAV(K)
0119              STIM = ISTIM

```

```

0120      WRITE (2,17) NTRL, AIX, A, S, DA, DS
0121 17    FORMAT (15,F7.1,4F8.0)
0122      V = 0
0123      A = 0.
0124      S = 0.
0125      DA = 0.
0126      DS = 0.
0127      IX = 0
0128      ITIME = 0
0129 260   CONTINUE
0130      IF (ITIME - ITIMS) 260,270,270
0131 270   IF (NTRL - INIT - ISESN + 1) 200,300,300
0132 280   CONTINUE
0133      GO TO 501
0134 C
0135 300   WRITE (2,18)
0136 18    FORMAT (4/)
0137      DO 310 I = 1,3
0138      DO 310 J = 1,3
0139      K = J - 1
0140      IF (VSAME(I,J) - 1) 310,304,306
0141 304   DEUSC(I,J) = 0.
0142      DEUSX(I,J) = 0.
0143      GO TO 302
0144 306   R = VSAME(I,J) - ISX(I,J)
0145      S = ISX(I,J)
0146      DEUSC(I,J) = SQRT ((DEUSC(I,J) - (ATSC(I,J)**2/R))/(R-1.))
0147      DEUSX(I,J) = SQRT ((DEUSX(I,J) - (ATSX(I,J)**2/S))/(S-1.))
0148      SDAWS(I,J) = SQRT ((SDAWS(I,J) - (TDAWS(I,J)**2/S))/(S-1.))
0149      IF (ISX(I,J) - 1) 320,320,322
0150 320   DEUSX(I,J) = 0.
0151      SDAWS(I,J) = 0.
0152 322   ATSC(I,J) = ATSC(I,J) / R
0153      ATSX(I,J) = ATSX(I,J) / S
0154      TDAWS(I,J) = TDAWS(I,J) / S
0155 302   WRITE (2,19) I,K,VSAME(I,J),ISX(I,J),
0156      1 ATSC(I,J),DEUSC(I,J),ATSX(I,J),DEUSX(I,J),
0157      2 TDAWS(I,J),SDAWS(I,J)
0158 19    FORMAT (12," = ",12,216,6F8.0)
0159 310   CONTINUE
0160      WRITE (2,20)
0161 20    FORMAT (/)
0162      IF (NDIFF - 1) 312,314,316
0163 314   DEUDC = 0.
0164      DEVDX = 0.
0165      GO TO 312
0166 316   R = NDIFF - IDX
0167      S = IDX
0168      DEUDC = SQRT ((DEUDC - (ATDC**2/R))/(R-1.))
0169      DEVDX = SQRT ((DEVDX - (ATDX**2/S))/(S-1.))
0170      SDAWD = SQRT ((SDAWD - (TDAWD**2/S))/(S-1.))
0171      IF (IDX - 1) 324,324,312
0172 324   DEVDX = 0.
0173      SDAWD = 0.
0174 312   I = 0
0175      J = 0
0176      ATDC = ATDC/R
0177      ATDX = ATDX/S
0178      TDAWD = TDAWD/S
0179      WRITE (2,19) I,J,NDIFF,IDX,ATDC,DEUDC,ATEX,DEVX,

```

```

0180      JERR = JERR + 1
0181      VER = VER + 1
0182      IBER = IBER + 1
0183      GO TO 240
0184 215    ATE = ILATE
0185      NUMRSCISTIM,IFREV) = NUMRSCISTIM,IFREV) + 1
0186      SUMCISTIM,IFREV) = SUMCISTIM,IFREV) + ATE
0187      SOSCISTIM,IFREV) = SOSCISTIM,IFREV) + ATE**2
0188      SUME = SUME + ATE
0189      BSUM = BSUM + ATE
0190      BSQS = BSQS + ATE**2
0191      IF (IBER) 240,240,230
0192 230    IROVGCISTIM,IFREV) = IROVGCISTIM,IFREV) + 1
0193      VER2 = VER2 + 1
0194      JERR = JERR + 1
0195 240    CONTINUE
0196 190    CONTINUE
0197      C
0198      ICNT = ICNT + 1
0199      IF (ICNT - NFEED) 300,310,300
0200 310    ICNT = 0
0201      CALL LIGHT
0202      C
0203      GO TO (355,330),IFPAY
0204 330    ER = VER
0205      SUME = SUME / (DI VR-ER)
0206      SUME = (AVER-SUME)/5DEV
0207      IF (SUME) 331,331,335
0208 335    ISUME = SUME
0209      IF (ISUME - 3) 340,340,341
0210 341    ISUME = 3
0211 340    IEARN = IEARN + ISUME*ISPD
0212 331    SUME = 0.
0213      VER = 0
0214      IF (JERR - 2) 345,345,350
0215 345    IEARN = IEARN + (IEEP/(JERR+1))
0216 350    IF (IPAYA - IEARN) 351,355,355
0217 351    IPAYA = IEARN
0218      GO TO (350,353),INEGP
0219 352    WRITE (2,22) NTRL,JERR,IPAYA
0220 22    FORMAT (3(15,1X))
0221      GO TO 360
0222 353    GERR = JERR
0223      GERR = 100. * (DI VR-GERR)/DI VR
0224      WRITE (2,31) NTRL,GERR,IPAYA
0225 31    FORMAT (15,2X,F5.1,2(14))
0226      GO TO 360
0227 355    GO TO (356,357),INEGP
0228 356    WRITE (2,22) NTRL,JERR
0229      GO TO 360
0230 357    GERR = JERR
0231      GERR = 100. * (DI VR-GERR)/DI VR
0232      WRITE (2,31) NTRL,GERR
0233      GO TO 360
0234 360    JERR = 0
0235      C
0236      C
0237      IF (ITIME) 360,361,361
0238 361    IF (NTR - INIT - ISESN + 1) 300,400,400
0239      C

```

```

0240 300 CONTINUE
0241 200 CONTINUE
0242 GO TO 530
0243 C
0244 C
0245 400 WRITE (2,25)
0246 GO TO (400,430),IFPAY
0247 430 I = IRWD + IEARN
0248 WRITE (2,26) IRWD,IEARN,I
0249 26 FORMAT (/,5X,14," CENTS R/FWD",/, "PLUS ",14," CENTS",/,
0250 1 2X,"= ",14," CENTS TO DATE")
0251 420 TRLS = NTRL - INIT - IEER + 1
0252 BSQS = SQRT ((BSQS-(BSUM**2/TRLS))/(TRLS-1.))
0253 BSUM = RSUM/TRLS
0254 WRITE (2,30) BSUM,BSQS,TRLS
0255 30 FORMAT (/,"MEAN RT ",F8.2," SDEV RT ",F8.2," OVER ",
0256 1 F7.1," TRIALS")
0257 WRITE (2,27) INIT,NTRL,(IDATE(I),I=1,10),(NAME(I),I=1,6)
0258 27 FORMAT (/,"TRIALS FROM ",16," TO ",16," ON ",10A2,
0259 1 " WITH ",6A2,///)
0260 DO 410 I = 1,2
0261 DO 409 J = 1,18
0262 IF (NUMRS(J,I)) 411,411,412
0263 412 TRLS = NUMRS(J,I)
0264 SOS(J,I) = SQRT ((SOS(J,I)-(SUM(J,I)**2/TRLS))/(TRLS-1.))
0265 SUM(J,I) = SUM(J,I)/TRLS
0266 411 K = J-3
0267 WRITE (2,41) K,NUMRS(J,I),SUM(J,I),SOS(J,I),IEARL(J,I),
0268 1 IRONG(J,I),ILATE(J,I)
0269 41 FORMAT (13,2X,15,2X,2F15.2,3I6)
0270 409 CONTINUE
0271 WRITE (2,32)
0272 32 FORMAT (/)
0273 410 CONTINUE
0274 WRITE (2,25)
0275 CALL WAIT
0276 GO TO 500
0277 END
0278 ENDS

```

TRANSMISSION CHARACTERISTICS OF FILTERS USED

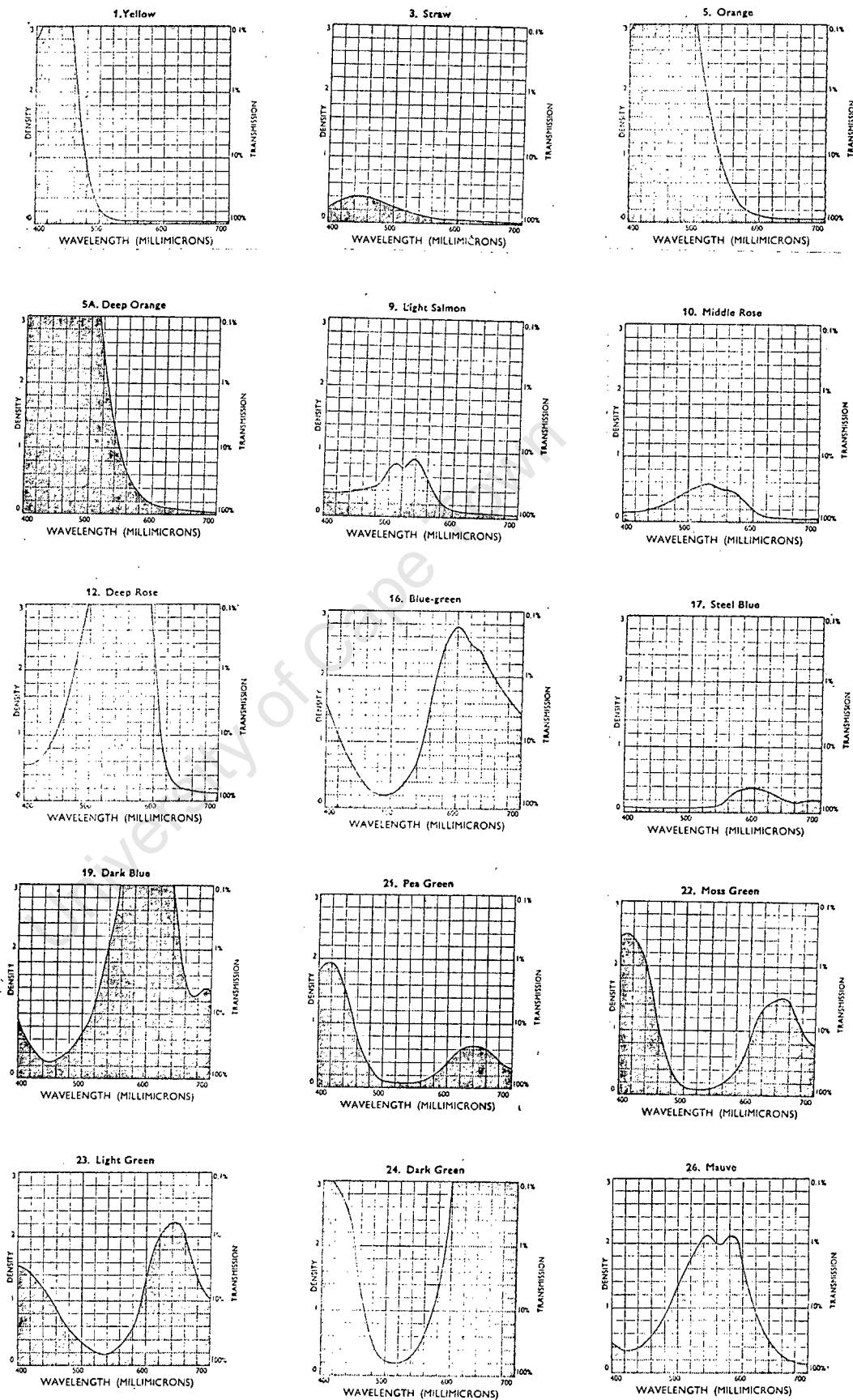
All filters used were "Cinemoid" acetate stage filters, manufactured by Messrs Rank Strand Electric Ltd, 29 King Street, Covent Garden, London, WC2E 8JH (available in U.S.A. from 3, Entin Road, Clifton, New Jersey, 07014). The transmission characteristics of those used in this study are shown overleaf.

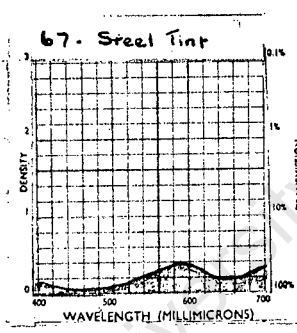
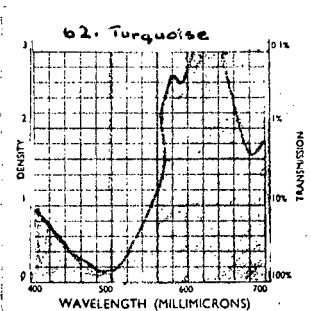
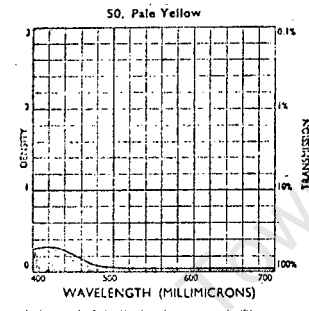
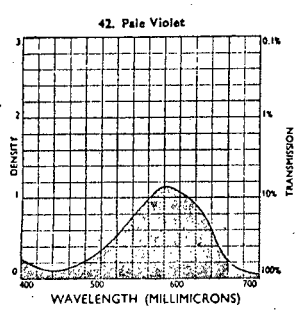
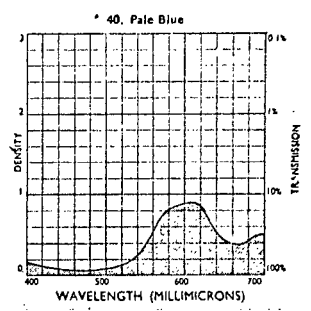
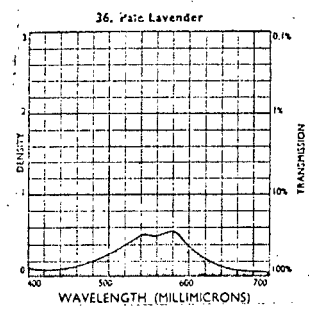
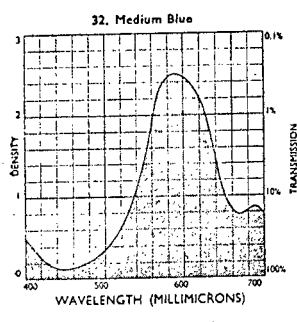
1. Conditioning of tone-contingent hue responses.
  - (a) Two-colour mixer. For filters used, see Appendix 1, p.246.
  - (b) Hue-attenuating and light-occluding goggles. For filters used, see Appendix 5, p.258.
2. Conditioning of gaze-contingent hue responses.
  - (a) Three-colour mixer. For filters used, see Appendix 1, p. 247.
  - (b) Two-colour mixer. Same as for tone-contingent study.
  - (c) Viewing filters.
    - (i) First subject (Paula)

Red filter: No. 9 (Light Salmon)  
Blue-Green filter: No. 40 (Pale Blue) in series with No. 50 (Pale Yellow)
    - (ii) Second subject (Kathryn)

Red filter: No. 10 (Middle Rose) in series with two sheets of No. 50 (Pale Yellow)  
Blue-Green Filter: No. 40 (Pale Blue) in series with No. 50 (Pale Yellow).







# Appendix 4

DATE: 17 FEB POST(VERBAL)

SUBJECT: ERIC

NEUTRAL RESPONSE - YES(1), NO(0) : 0

TIMET TIMEC TIMEP  
2 1250 500

BLOCT BLOCN NBLOC  
16 2 8

PAUSE

| STIM | NO TONES |   |   |            |    | LOW TONE |   |   |            |      | HIGH TONE |   |   |            |       |
|------|----------|---|---|------------|----|----------|---|---|------------|------|-----------|---|---|------------|-------|
|      | R        | G | N | AVE        | SD | R        | G | N | AVE        | SD   | R         | G | N | AVE        | SD    |
| -2   | 0        | 0 | 0 | 0000000000 |    | 0        | 0 | 0 | 0000000000 |      | 0         | 0 | 0 | 0000000000 |       |
| -1   | 0        | 0 | 0 | 0000000000 |    | 0        | 0 | 0 | 0000000000 |      | 0         | 0 | 0 | 0000000000 |       |
| 0    | 16       | 0 | 0 | 0000000000 |    | 0        | 8 | 0 | 904.       | 193. | 0         | 8 | 0 | 968.       | 159.  |
| 1    | 16       | 0 | 0 | 0000000000 |    | 0        | 8 | 0 | 931.       | 162. | 0         | 8 | 0 | 847.       | 221.  |
| 2    | 16       | 0 | 0 | 0000000000 |    | 1        | 7 | 0 | 717.       | 116. | 0         | 8 | 0 | 965.       | 198.  |
| 3    | 16       | 0 | 0 | 0000000000 |    | 0        | 8 | 0 | 780.       | 110. | 0         | 8 | 0 | 750.       | 182.  |
| 4    | 16       | 0 | 0 | 0000000000 |    | 0        | 8 | 0 | 894.       | 154. | 1         | 7 | 0 | 739.       | 290.  |
| 5    | 16       | 0 | 0 | 0000000000 |    | 1        | 7 | 0 | 925.       | 98.  | 0         | 8 | 0 | 752.       | 119.  |
| 6    | 16       | 0 | 0 | 0000000000 |    | 1        | 7 | 0 | 919.       | 194. | 4         | 4 | 0 | 1104.      | 161.  |
| 7    | 16       | 0 | 0 | 0000000000 |    | 3        | 5 | 0 | 1002.      | 231. | 0         | 8 | 0 | 858.       | 110.  |
| 8    | 16       | 0 | 0 | 0000000000 |    | 5        | 3 | 0 | 986.       | 115. | 6         | 2 | 0 | 1052.      | 157.  |
| 9    | 16       | 0 | 0 | 0000000000 |    | 8        | 0 | 0 | 957.       | 134. | 6         | 2 | 0 | 862.       | 110.  |
| 10   | 16       | 0 | 0 | 0000000000 |    | 7        | 1 | 0 | 878.       | 118. | 7         | 1 | 0 | 4040.      | 8168. |
| 11   | 16       | 0 | 0 | 0000000000 |    | 8        | 0 | 0 | 974.       | 156. | 7         | 1 | 0 | 974.       | 170.  |
| 12   | 16       | 0 | 0 | 0000000000 |    | 8        | 0 | 0 | 1019.      | 117. | 7         | 1 | 0 | 3124.      | 5543. |
| 13   | 16       | 0 | 0 | 0000000000 |    | 8        | 0 | 0 | 864.       | 102. | 8         | 0 | 0 | 896.       | 147.  |
| 14   | 16       | 0 | 0 | 0000000000 |    | 8        | 0 | 0 | 876.       | 170. | 7         | 1 | 0 | 1725.      | 2105. |
| 15   | 16       | 0 | 0 | 0000000000 |    | 8        | 0 | 0 | 932.       | 154. | 8         | 0 | 0 | 848.       | 135.  |

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: COMPUTER PRINTOUT OF  
PRE- AND POST-TRAINING TEST RESULTS

# Appendix 4

ABRAMOVITZ - PH D.H

DATE : 9 FEB

SUBJECT : ARNOLD

TIMET TIMEC TIMEF TIMEP  
800 800 500 500

NFEED PNEG1 PNEG2 PPOS1 PPOS2 +OR-F  
16 2 2 2 2 2

DIGITIZER LIMITS : L,M,H : 5.5 6.5 7.5

STARTING TRIAL NUMBER : 1537

PAUSE

1600 81.2  
1664 92.2  
1728 89.1  
1792 89.1  
1856 92.2  
1920 93.7  
1984 85.9  
2048 85.9

MEAN RT 483.64 SDEV RT 110.48 OVER 507.0 TRIALS

TRIALS FROM 1537 TO 2048 ON 9 FEB

WITH ARNOLD

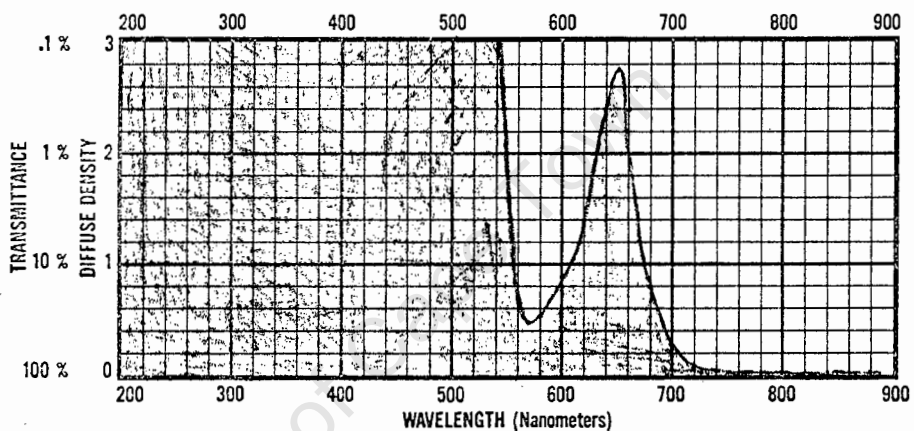
|    |     |        |        |   |   |   |
|----|-----|--------|--------|---|---|---|
| -2 | 104 | 443.31 | 87.99  | 0 | 2 | 0 |
| -1 | 103 | 451.03 | 92.36  | 0 | 1 | 1 |
| 0  | 14  | 473.29 | 92.42  | 0 | 0 | 0 |
| 1  | 13  | 529.00 | 131.05 | 0 | 1 | 1 |
| 2  | 14  | 550.86 | 144.80 | 0 | 0 | 0 |
| 3  | 14  | 474.07 | 125.56 | 0 | 0 | 0 |
| 4  | 8   | 500.25 | 117.38 | 0 | 0 | 0 |
| 5  | 8   | 485.87 | 126.32 | 0 | 1 | 0 |
| 6  | 8   | 490.37 | 114.86 | 0 | 1 | 0 |
| 7  | 7   | 560.43 | 135.51 | 0 | 1 | 1 |
| 8  | 8   | 587.12 | 141.40 | 0 | 2 | 0 |
| 9  | 8   | 551.62 | 52.04  | 0 | 0 | 0 |
| 10 | 7   | 495.86 | 98.31  | 0 | 0 | 1 |
| 11 | 8   | 515.50 | 80.30  | 0 | 0 | 0 |
| 12 | 14  | 546.71 | 106.31 | 0 | 0 | 0 |
| 13 | 14  | 519.71 | 111.19 | 0 | 0 | 0 |
| 14 | 14  | 534.21 | 115.97 | 0 | 0 | 0 |
| 15 | 14  | 447.43 | 98.82  | 0 | 0 | 0 |
| -2 | 24  | 447.79 | 116.84 | 0 | 1 | 0 |
| -1 | 24  | 479.67 | 81.95  | 0 | 0 | 0 |
| 0  | 2   | 701.00 | 50.91  | 0 | 1 | 0 |
| 1  | 2   | 370.50 | 26.16  | 0 | 2 | 0 |
| 2  | 2   | 327.50 | 45.96  | 0 | 2 | 0 |
| 3  | 2   | 400.00 | 57.98  | 0 | 2 | 0 |
| 4  | 8   | 497.37 | 91.76  | 0 | 4 | 0 |
| 5  | 8   | 524.25 | 86.89  | 0 | 3 | 0 |
| 6  | 8   | 601.87 | 154.45 | 0 | 4 | 0 |
| 7  | 8   | 549.25 | 64.56  | 0 | 8 | 0 |
| 8  | 8   | 550.37 | 48.03  | 0 | 4 | 0 |
| 9  | 8   | 527.50 | 150.27 | 0 | 3 | 0 |
| 10 | 8   | 536.62 | 129.88 | 0 | 3 | 0 |
| 11 | 8   | 530.62 | 126.06 | 0 | 5 | 0 |
| 12 | 1   | 519.00 | 519.00 | 0 | 0 | 1 |
| 13 | 2   | 319.00 | 141.42 | 0 | 1 | 0 |
| 14 | 2   | 469.00 | 42.43  | 0 | 0 | 0 |
| 15 | 2   | 592.00 | 19.80  | 0 | 1 | 0 |

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: COMPUTER PRINTOUT OF  
RESULTS FOR FULL EXPERIMENTAL SESSION

## CONDITIONING OF TONE-CONTINGENT HUE RESPONSES

Description of hue-attenuating and light-occluding goggles worn by four subjects

The goggles used were of the type used by ski-ers. For the first three subjects, Stephen, Stan and Steve, an attempt was made to mimic the narrow bandpass Kodak Wratten No.90 filter, whose transmission characteristics are shown below.



It was found that Cinemoid Filter 5A (Deep Orange) in series with no. 24 (Dark Green) produced a similar effect.

For the fourth subject, Nevil, the filters used were no. 5A (Deep Orange) and no. 19 (Dark Blue), in series, which passed a small amount of light in the long wave region.

Transmission characteristics of these filters are to be found in Appendix 3, p. 253.

## Appendix 6

## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: STEPHEN DISTRIBUTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY  
31 JAN + 14 FEB PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE,  
BLUE-GREEN TO RED,  $g(0)$  to  $r(15)$ , CONTINGENT ON LOW TONE (200 Hz) IN LEFT EAR AND  
HIGH TONE (300 Hz) IN RIGHT EAR RESPECTIVELY ( TRANSCRIBED DIRECTLY FROM COMPUTER  
PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGI-  
TIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECT-  
ION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE = 10 ).

| PRE- OR POST-TRAINING?                   |                  | PRE-TRAINING |       | POST-TRAINING |         |           |       |          |       |    |        |  |  |  |
|------------------------------------------|------------------|--------------|-------|---------------|---------|-----------|-------|----------|-------|----|--------|--|--|--|
| TIME PARAMETERS: TONE (PRECEDING COLOUR) |                  | 1.0          |       | 1.0           |         |           |       |          |       |    |        |  |  |  |
| (IN SECS.) TONE + COLOUR                 |                  | 1.0          |       | 1.0           |         |           |       |          |       |    |        |  |  |  |
| POST-RESPONSE INTERVAL                   |                  | 1.0          |       | 0.5           |         |           |       |          |       |    |        |  |  |  |
| MODE OF                                  | KEY-PRESS WITH   | VERBAL ONLY  |       | KEY-PRESS     |         | KEY-PRESS |       |          |       |    |        |  |  |  |
| RESPONSE:                                | CONCOMITANT      | OR           |       | MONITORED     |         | LOW HIGH  |       | LOW HIGH |       |    |        |  |  |  |
|                                          | VERBALIZATIONS   | BY OPERATOR  |       | R G R G       |         | R G R G   |       | R G R G  |       |    |        |  |  |  |
| (Unsaturated Blue-Green)                 |                  | 0            | 1     | 9             | 1       | 9         | 0     | 10       | 0     | 10 |        |  |  |  |
|                                          |                  | 1            | 0     | 10            | 0       | 10        | 0     | 10       | 0     | 10 |        |  |  |  |
|                                          |                  | 2            | 0     | 10            | 1       | 9         | 0     | 10       | 0     | 10 |        |  |  |  |
|                                          |                  | 3            | 0     | 10            | 1       | 9         | 0     | 10       | 0     | 10 |        |  |  |  |
| Distributions                            |                  | 4            | 0     | 10            | 0       | 10        | 0     | 10       | 0     | 10 |        |  |  |  |
| digitized                                | in               | 5            | 2     | 8             | 0       | 10        | 0     | 10       | 0     | 10 |        |  |  |  |
| settings                                 | terms            | 6            | 0     | 10            | 0       | 10        | 1     | 9        | 0     | 10 |        |  |  |  |
| of                                       | of               | 7            | 0     | 10            | 0       | 10        | 0     | 10       | 0     | 10 |        |  |  |  |
| colour-mixer                             | raw              | 8            | 3     | 7             | 1       | 9         | 0     | 10       | 0     | 10 |        |  |  |  |
|                                          | scores           | 9            | 1     | 9             | 7       | 3         | 0     | 10       | 0     | 10 |        |  |  |  |
|                                          |                  | 10           | 5     | 5             | 9       | 1         | 1     | 9        | 0     | 10 |        |  |  |  |
|                                          |                  | 11           | 9     | 1             | 5       | 5         | 5     | 5        | 5     | 5  |        |  |  |  |
|                                          |                  | 12           | 6     | 4             | 8       | 2         | 6     | 4        | 5     | 5  |        |  |  |  |
|                                          |                  | 13           | 8     | 2             | 9       | 1         | 10    | 0        | 7     | 3  |        |  |  |  |
| (Unsaturated Red)                        |                  | 14           | 9     | 1             | 8       | 2         | 10    | 0        | 8     | 2  |        |  |  |  |
|                                          |                  | 15           | 8     | 2             | 10      | 0         | 10    | 0        | 7     | 3  |        |  |  |  |
| MEAN REACTION-TIME (SECS.)               |                  |              | .693  |               | .704    |           | .650  |          | .567  |    |        |  |  |  |
| RTs ON VERBAL TESTS                      |                  | .5           | 1     |               |         |           | 0     |          | 0     |    |        |  |  |  |
| INCLUDE OPERATOR'S                       |                  | 1.5          | 0     |               | 1       |           | 0     |          | 0     |    |        |  |  |  |
| MONITORING TIMES                         |                  | 2.5          | 0     |               | 2       |           | 0     |          | 0     |    |        |  |  |  |
| Boundaries, Distributions                |                  | 3.5          | 0     |               | 1       |           | 0     |          | 0     |    |        |  |  |  |
| digitized                                | in terms         | 4.5          | 2     |               | 0       |           | 0     |          | 0     |    |        |  |  |  |
| settings                                 | of               | 5.5          | 2     |               | 0       |           | 1     |          | 0     |    |        |  |  |  |
| of                                       | derived          | 6.5          | 0     |               | 0       |           | 1     |          | 0     |    |        |  |  |  |
| colour-mixer                             | "achromaticness" | 7.5          | 3     |               | 1       |           | 0     |          | 0     |    |        |  |  |  |
|                                          | scores           | 8.5          | 4     |               | 8       |           | 0     |          | 0     |    |        |  |  |  |
|                                          |                  | 9.5          | 6     |               | 4       |           | 1     |          | 0     |    |        |  |  |  |
|                                          |                  | 10.5         | 6     |               | 6       |           | 6     |          | 5     |    |        |  |  |  |
|                                          |                  | 11.5         | 5     |               | 7       |           | 9     |          | 10    |    |        |  |  |  |
|                                          |                  | 12.5         | 6     |               | 3       |           | 4     |          | 8     |    |        |  |  |  |
|                                          |                  | 13.5         | 3     |               | 3       |           | 0     |          | 5     |    |        |  |  |  |
|                                          |                  | 14.5         | 3     |               | 2       |           | 0     |          | 5     |    |        |  |  |  |
| Sample Sizes                             |                  |              | 41    |               | 39      |           | 22    |          | 33    |    |        |  |  |  |
| Sample Means                             |                  |              | 10.09 |               | 9.60    |           | 11.82 |          | 13.38 |    |        |  |  |  |
| Sample SDs                               |                  |              | 3.033 |               | 3.444   |           | 1.756 |          | 1.302 |    |        |  |  |  |
| Medians, $Q_2$                           |                  |              | 10.42 |               | 10.25   |           | 11.22 |          | 12.19 |    |        |  |  |  |
| First Quartiles, $Q_1$                   |                  |              | 9.54  |               | 8.47    |           | 10.42 |          | 11.33 |    |        |  |  |  |
| Third Quartiles, $Q_3$                   |                  |              | 13.25 |               | 11.75   |           | 11.83 |          | 13.35 |    |        |  |  |  |
| Interquartile Ranges, $Q_3 - Q_1$        |                  |              | 3.71  |               | 3.28    |           | 1.42  |          | 2.03  |    |        |  |  |  |
| Mean Interquartile Range, $J$            |                  |              | 3.495 |               | 1.721   |           |       |          |       |    |        |  |  |  |
| Mean Diffs. in "achr" score units        |                  |              | -.49  |               | 1.530   |           |       |          |       |    | +2.02  |  |  |  |
| Mdn. Diffs. in "achr" score units        |                  |              | -.167 |               | .965    |           |       |          |       |    | +1.132 |  |  |  |
| Mean Differences in J-units              |                  |              | -.140 |               | .889    |           |       |          |       |    | +1.029 |  |  |  |
| Mdn. Differences in J-units              |                  |              | -.047 |               | .561    |           |       |          |       |    | +0.608 |  |  |  |
| Mean Diff. t value                       |                  |              | .667  |               | 3.71    |           |       |          |       |    | 2.130  |  |  |  |
| DF                                       |                  |              | 78    |               | 53      |           |       |          |       |    | 131    |  |  |  |
| p                                        |                  |              | .507  |               | .000500 |           |       |          |       |    | .0350  |  |  |  |
| Direction                                |                  |              | -ve   |               | +ve     |           |       |          |       |    | +ve    |  |  |  |
| Median Diff. Chi-Sq.                     |                  |              | 0     |               | 4.15    |           |       |          |       |    |        |  |  |  |
| DF                                       |                  |              | 1     |               | 1       |           |       |          |       |    |        |  |  |  |
| p                                        |                  |              | .99   |               | .0416   |           |       |          |       |    |        |  |  |  |
| Direction                                |                  |              | -ve   |               | +ve     |           |       |          |       |    |        |  |  |  |

CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: STAN DISTRIBUTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY  
7 FEB PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE,  
BLUE-GREEN TO RED, g(0) to r(15), CONTINGENT ON LOW TONE (250 Hz) IN LEFT EAR AND  
HIGH TONE (390 Hz) IN RIGHT EAR RESPECTIVELY ( TRANSCRIBED DIRECTLY FROM COMPUTER  
PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGI-  
TIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECT-  
ION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE =10 ).

| PRE- OR POST-TRAINING?                               |                            | PRE-TRAINING |        |       |    | POST-TRAINING |        |       |    |          |   |   |   |
|------------------------------------------------------|----------------------------|--------------|--------|-------|----|---------------|--------|-------|----|----------|---|---|---|
| TIME PARAMETERS: TONE (PRECEDING COLOUR)             |                            | 1.0          |        |       |    | 1.0           |        |       |    |          |   |   |   |
| (IN SECS.)                                           |                            | 1.0          |        |       |    | 1.0           |        |       |    |          |   |   |   |
| TONE + COLOUR                                        |                            |              |        |       |    |               |        |       |    |          |   |   |   |
| POST-RESPONSE INTERVAL                               |                            | 0.5          |        |       |    | 0.5           |        |       |    |          |   |   |   |
| MODE OF RESPONSE:                                    | KEY-PRESS WITH             | KEY-PRESS    |        |       |    | KEY-PRESS     |        |       |    |          |   |   |   |
|                                                      | CONCOMITANT OR             | LOW HIGH     |        |       |    | LOW HIGH      |        |       |    | LOW HIGH |   |   |   |
|                                                      | VERBALIZATIONS BY OPERATOR | R            | G      | R     | G  | R             | G      | R     | G  | R        | G | R | G |
| (Unsaturated Blue-Green)                             |                            | 0            | 1      | 9     | 2  | 8             | 0      | 10    | 0  | 10       |   |   |   |
|                                                      |                            | 1            | 2      | 8     | 0  | 10            | 0      | 10    | 0  | 10       |   |   |   |
|                                                      |                            | 2            | 2      | 8     | 0  | 10            | 0      | 10    | 0  | 10       |   |   |   |
|                                                      |                            | 3            | 0      | 10    | 1  | 9             | 1      | 9     | 0  | 10       |   |   |   |
| Distributions                                        |                            | 4            | 0      | 10    | 0  | 10            | 0      | 10    | 0  | 10       |   |   |   |
| digitized in                                         |                            | 5            | 2      | 8     | 3  | 7             | 1      | 9     | 0  | 10       |   |   |   |
| settings terms                                       |                            | 6            | 7      | 3     | 2  | 8             | 4      | 6     | 5  | 5        |   |   |   |
| of of                                                |                            | 7            | 4      | 6     | 3  | 7             | 6      | 4     | 1  | 9        |   |   |   |
| colour-mixer raw                                     |                            | 8            | 9      | 1     | 9  | 1             | 9      | 1     | 8  | 2        |   |   |   |
|                                                      |                            | 9            | 9      | 1     | 9  | 1             | 7      | 3     | 8  | 2        |   |   |   |
|                                                      |                            | 10           | 9      | 1     | 10 | 0             | 10     | 0     | 8  | 2        |   |   |   |
| scores                                               |                            | 11           | 0      | 0     | 9  | 1             | 10     | 0     | 7  | 3        |   |   |   |
|                                                      |                            | 12           | 9      | 1     | 9  | 1             | 10     | 0     | 9  | 1        |   |   |   |
|                                                      |                            | 13           | 10     | 0     | 9  | 1             | 10     | 0     | 10 | 0        |   |   |   |
| (Unsaturated Red)                                    |                            | 14           | 10     | 0     | 10 | 0             | 10     | 0     | 10 | 0        |   |   |   |
|                                                      |                            | 15           | 9      | 1     | 10 | 0             | 10     | 0     | 10 | 0        |   |   |   |
| MEAN REACTION-TIME (SECS.)                           |                            |              |        |       |    |               |        |       |    |          |   |   |   |
| RTs ON VERBAL TESTS                                  |                            | .5           | 3      | 2     |    |               | 0      | 0     |    |          |   |   |   |
| INCLUDE OPERATOR'S                                   |                            | 1.5          | 4      | 0     |    |               | 0      | 0     |    |          |   |   |   |
| MONITORING TIMES                                     |                            | 2.5          | 2      | 1     |    |               | 1      | 0     |    |          |   |   |   |
| Boundaries, Distributions                            |                            | 3.5          | 0      | 1     |    |               | 1      | 0     |    |          |   |   |   |
| digitized in terms                                   |                            | 4.5          | 2      | 3     |    |               | 1      | 0     |    |          |   |   |   |
| settings of                                          |                            | 5.5          | 9      | 5     |    |               | 5      | 5     |    |          |   |   |   |
| of derived                                           |                            | 6.5          | 9      | 5     |    |               | 10     | 6     |    |          |   |   |   |
| colour-mixer "achromaticness"                        |                            | 7.5          | 7      | 8     |    |               | 5      | 9     |    |          |   |   |   |
| scores                                               |                            | 8.5          | 2      | 2     |    |               | 4      | 4     |    |          |   |   |   |
|                                                      |                            | 9.5          | 2      | 0     |    |               | 3      | 4     |    |          |   |   |   |
|                                                      |                            | 10.5         | 1      | 1     |    |               | 0      | 5     |    |          |   |   |   |
|                                                      |                            | 11.5         | 0      | 2     |    |               | 0      | 4     |    |          |   |   |   |
|                                                      |                            | 12.5         | 1      | 2     |    |               | 0      | 1     |    |          |   |   |   |
|                                                      |                            | 13.5         | 0      | 1     |    |               | 0      | 0     |    |          |   |   |   |
|                                                      |                            | 14.5         | 1      | 0     |    |               | 0      | 0     |    |          |   |   |   |
| Sample Sizes                                         |                            |              | 43     | 33    |    |               | 30     | 38    |    |          |   |   |   |
| Sample Means                                         |                            |              | 5.919  | 6.954 |    |               | 6.767  | 8.342 |    |          |   |   |   |
| Sample SDs                                           |                            |              | 3.041  | 3.113 |    |               | 1.660  | 2.034 |    |          |   |   |   |
| Medians, Q <sub>2</sub>                              |                            |              | 6.17   | 6.90  |    |               | 6.70   | 7.89  |    |          |   |   |   |
| First Quartiles, Q <sub>1</sub>                      |                            |              | 4.83   | 5.25  |    |               | 5.90   | 6.75  |    |          |   |   |   |
| Third Quartiles, Q <sub>3</sub>                      |                            |              | 7.46   | 7.97  |    |               | 7.90   | 10.10 |    |          |   |   |   |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> |                            |              | 2.59   | 2.72  |    |               | 2.00   | 3.35  |    |          |   |   |   |
| Mean Interquartile Range, J                          |                            |              | 2.654  |       |    |               | 2.675  |       |    |          |   |   |   |
| Mean Diffs. in "achr" score units                    |                            |              | +1.036 |       |    |               | +1.575 |       |    |          |   |   |   |
| Mdn. Diffs. in "achr" score units                    |                            |              | + .733 |       |    |               | +1.189 |       |    |          |   |   |   |
| Mean Differences in J-units                          |                            |              | + .390 |       |    |               | + .590 |       |    |          |   |   |   |
| Mdn. Differences in J-units                          |                            |              | + .276 |       |    |               | + .444 |       |    |          |   |   |   |
| Mean Diff. t value                                   |                            |              | 1.457  |       |    |               | 3.434  |       |    |          |   |   |   |
| DF                                                   |                            |              | 74     |       |    |               | 66     |       |    |          |   |   |   |
| P                                                    |                            |              | .149   |       |    |               | .00163 |       |    |          |   |   |   |
| Direction                                            |                            |              | +ve    |       |    |               | +ve    |       |    |          |   |   |   |
| Median Diff. Chi-Sq.                                 |                            |              | 1.93   |       |    |               | 2.07   |       |    |          |   |   |   |
| DF                                                   |                            |              | 1      |       |    |               | 1      |       |    |          |   |   |   |
| P                                                    |                            |              | .165   |       |    |               | .150   |       |    |          |   |   |   |
| Direction                                            |                            |              | +ve    |       |    |               | +ve    |       |    |          |   |   |   |
|                                                      |                            |              |        |       |    |               |        |       |    |          |   |   |   |

PRE- & POST-  
NETT DIFFS.

App. 6

## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: STEVE  
9 FEB

DISTRIBUTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE, BLUE-GREEN TO RED, g(0) to r(15), CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR RESPECTIVELY (TRANSCRIBED DIRECTLY FROM COMPUTER PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE = 10).

| PRE- OR POST-TRAINING?                               |                            | PRE-TRAINING |       |           |       | POST-TRAINING |       |    |    | POST-TRAINING |    |    |    |    |
|------------------------------------------------------|----------------------------|--------------|-------|-----------|-------|---------------|-------|----|----|---------------|----|----|----|----|
| TIME PARAMETERS: TONE (PRECEDING COLOUR)             |                            | 1.0          |       |           |       | 0.6           |       |    |    | 1.0           |    |    |    |    |
| (IN SECS.)                                           |                            | 1.0          |       |           |       | 0.4           |       |    |    | 1.0           |    |    |    |    |
| POST-RESPONSE INTERVAL                               |                            | 0.5          |       |           |       | 0.4           |       |    |    | 0.5           |    |    |    |    |
| MODE OF RESPONSE:                                    | KEY-PRESS WITH             | VERBAL       |       |           |       | KEY-PRESS     |       |    |    | VERBAL        |    |    |    |    |
|                                                      | CONCOMITANT OR MONITORED   | LOW-HIGH     |       |           |       | LOW-HIGH      |       |    |    | LOW-HIGH      |    |    |    |    |
|                                                      | VERBALIZATIONS BY OPERATOR | R            | G     | R         | G     | R             | G     | R  | G  | R             | G  | R  | G  |    |
| (Unsaturated Blue-Green)                             |                            | 0            | 0     | 10        | 0     | 10            | 3     | 7  | 0  | 10            | 0  | 10 | 0  | 10 |
|                                                      |                            | 1            | 0     | 10        | 0     | 10            | 1     | 9  | 0  | 10            | 0  | 10 | 0  | 10 |
|                                                      |                            | 2            | 0     | 10        | 0     | 10            | 3     | 7  | 1  | 9             | 0  | 10 | 0  | 10 |
|                                                      |                            | 3            | 0     | 10        | 0     | 10            | 1     | 9  | 0  | 10            | 0  | 10 | 0  | 10 |
| Distributions                                        |                            | 4            | 0     | 10        | 0     | 10            | 0     | 10 | 2  | 8             | 0  | 10 | 0  | 10 |
| digitized in                                         |                            | 5            | 0     | 10        | 1     | 9             | 4     | 6  | 3  | 7             | 0  | 10 | 0  | 10 |
| settings terms                                       |                            | 6            | 2     | 8         | 3     | 7             | 10    | 0  | 2  | 8             | 5  | 5  | 7  | 3  |
| of of                                                |                            | 7            | 8     | 2         | 5     | 5             | 10    | 0  | 4  | 6             | 9  | 1  | 5  | 5  |
| colour-mixer raw                                     |                            | 8            | 10    | 0         | 9     | 1             | 10    | 0  | 7  | 3             | 10 | 0  | 10 | 0  |
|                                                      |                            | 9            | 10    | 0         | 10    | 0             | 10    | 0  | 7  | 3             | 10 | 0  | 10 | 0  |
| scores                                               |                            | 10           | 10    | 0         | 10    | 0             | 9     | 1  | 10 | 0             | 10 | 0  | 10 | 0  |
|                                                      |                            | 11           | 10    | 0         | 10    | 0             | 10    | 0  | 4  | 6             | 10 | 0  | 10 | 0  |
|                                                      |                            | 12           | 10    | 0         | 10    | 0             | 7     | 3  | 7  | 3             | 10 | 0  | 10 | 0  |
|                                                      |                            | 13           | 10    | 0         | 10    | 0             | 10    | 0  | 7  | 3             | 10 | 0  | 10 | 0  |
| (Unsaturated Red)                                    |                            | 14           | 10    | 0         | 10    | 0             | 10    | 0  | 9  | 1             | 10 | 0  | 10 | 0  |
|                                                      |                            | 15           | 10    | 0         | 10    | 0             | 10    | 0  | 6  | 4             | 10 | 0  | 10 | 0  |
| MEAN REACTION-TIME (SECS.)                           |                            | 1.714        | 1.915 | 1.625     | 1.553 | 1.378         | 1.333 |    |    |               |    |    |    |    |
| RTs ON VERBAL TESTS                                  |                            | .5           | 0     | 0         | 0     | 4             | 0     | 0  | 0  | 0             | 0  | 0  | 0  | 0  |
| INCLUDE OPERATOR'S                                   |                            | 1.5          | 0     | 0         | 0     | 4             | 1     | 0  | 0  | 0             | 0  | 0  | 0  | 0  |
| MONITORING TIMES                                     |                            | 2.5          | 0     | 0         | 0     | 4             | 1     | 0  | 0  | 0             | 0  | 0  | 0  | 0  |
| Boundaries, Distributions                            |                            | 3.5          | 0     | 0         | 0     | 1             | 2     | 0  | 0  | 0             | 0  | 0  | 0  | 0  |
| digitized in terms                                   |                            | 4.5          | 0     | 0         | 1     | 4             | 5     | 0  | 0  | 0             | 0  | 0  | 0  | 0  |
| settings of                                          |                            | 5.5          | 2     | 4         | 6     | 5             | 5     | 5  | 7  |               |    |    |    |    |
| of derived                                           |                            | 6.5          | 10    | 8         | 0     | 6             | 6     | 6  | 8  |               |    |    |    |    |
| colour-mixer "achromaticness"                        |                            | 7.5          | 2     | 6         | 0     | 9             | 1     | 5  |    |               |    |    |    |    |
| scores                                               |                            | 8.5          | 0     | 0         | 1     | 0             | 6     | 0  | 0  |               |    |    |    |    |
|                                                      |                            | 9.5          | 0     | 0         | 1     | 3             | 0     | 0  | 0  |               |    |    |    |    |
|                                                      |                            | 10.5         | 0     | 0         | 1     | 6             | 0     | 0  | 0  |               |    |    |    |    |
|                                                      |                            | 11.5         | 0     | 0         | 3     | 9             | 0     | 0  | 0  |               |    |    |    |    |
|                                                      |                            | 12.5         | 0     | 0         | 3     | 6             | 0     | 0  | 0  |               |    |    |    |    |
|                                                      |                            | 13.5         | 0     | 0         | 0     | 4             | 0     | 0  | 0  |               |    |    |    |    |
|                                                      |                            | 14.5         | 0     | 0         | 0     | 5             | 0     | 0  | 0  |               |    |    |    |    |
| Sample Sizes                                         |                            | 14           | 20    | 31        | 68    | 12            | 20    |    |    |               |    |    |    |    |
| Sample Means                                         |                            | 6.50         | 6.60  | 9.31      | 13.04 | 6.17          | 6.40  |    |    |               |    |    |    |    |
| Sample SDs                                           |                            | 5.55         | 9.68  | 4.094     | 3.361 | 6.51          | 7.88  |    |    |               |    |    |    |    |
| Medians, Q <sub>2</sub>                              |                            | 6.50         | 6.63  | 3.63      | 5.83  | 6.17          | 6.38  |    |    |               |    |    |    |    |
| First Quartiles, Q <sub>1</sub>                      |                            | 6.15         | 6.00  | 1.94      | 6.50  | 5.60          | 5.71  |    |    |               |    |    |    |    |
| Third Quartiles, Q <sub>3</sub>                      |                            | 6.85         | 7.33  | 7.05      | 11.78 | 6.67          | 7.00  |    |    |               |    |    |    |    |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> |                            | .70          | 1.33  | 5.06      | 5.28  | 1.07          | 1.29  |    |    |               |    |    |    |    |
| Mean Intersubject Range, J                           |                            | 1.017        |       | 5.170     |       | 1.176         |       |    |    |               |    |    |    |    |
| Mean Diffs. in "achr" score units                    |                            | +1.00        |       | +3.138    |       | +2.33         |       |    |    |               |    |    |    |    |
| Mdn. Diffs. in "achr" score units                    |                            | +1.25        |       | +5.208    |       | +2.08         |       |    |    |               |    |    |    |    |
| Mean Differences in J-units                          |                            | +1.097       |       | +1.24     |       | +1.98         |       |    |    |               |    |    |    |    |
| Mdn. Differences in J-units                          |                            | +1.23        |       | +1.006    |       | +1.77         |       |    |    |               |    |    |    |    |
| Mean Diff. t value                                   |                            | -3.48        |       | 4.786     |       | 8.63          |       |    |    |               |    |    |    |    |
| DF                                                   |                            | 32           |       | 97        |       | 30            |       |    |    |               |    |    |    |    |
| P                                                    |                            | .130         |       | .00000609 |       | .345          |       |    |    |               |    |    |    |    |
| Direction                                            |                            | +ve          |       | +ve       |       | +ve           |       |    |    |               |    |    |    |    |
| Median Diff. Chi-Sq.                                 |                            | .12          |       | 8.80      |       | .13           |       |    |    |               |    |    |    |    |
| DF                                                   |                            | 1            |       | 1         |       | 1             |       |    |    |               |    |    |    |    |
| P                                                    |                            | .729         |       | .00301    |       | .718          |       |    |    |               |    |    |    |    |
| Direction                                            |                            | +ve          |       | +ve       |       | +ve           |       |    |    |               |    |    |    |    |

VERBAL  
PRE- & POST-  
NETT DIFFS.

+1.133  
+1.083  
+1.101  
+1.054  
+1.335  
62  
-138



## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: NEVIL  
10 FEB

DISTRIBUTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE, BLUE-GREEN TO RED, g(0) to r(15), CONTINGENT ON LOW TONE (200 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR RESPECTIVELY (TRANSCRIBED DIRECTLY FROM COMPUTER PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE = 10).

| PRE- OR POST-TRAINING?                                                                 |                          | PRE-TRAINING |       | POST-TRAINING |       |          |    |          |    |    |
|----------------------------------------------------------------------------------------|--------------------------|--------------|-------|---------------|-------|----------|----|----------|----|----|
| TIME PARAMETERS: TONE (PRECEDING COLOUR)                                               |                          | .5           |       | .5            |       |          |    |          |    |    |
| (IN SECS.) TONE + COLOUR                                                               |                          | 1.0          |       | 1.0           |       |          |    |          |    |    |
| POST-RESPONSE INTERVAL                                                                 |                          | .5           |       | .5            |       |          |    |          |    |    |
| MODE OF RESPONSE:                                                                      | KEY-PRESS WITH           | VERBAL       |       | KEY-PRESS     |       |          |    |          |    |    |
|                                                                                        | CONCOMITANT OR MONITORED | LOW HIGH     |       | LOW HIGH      |       | LOW HIGH |    | LOW HIGH |    |    |
| VERBALIZATIONS BY OPERATOR                                                             |                          | R            | G     | R             | G     | R        | G  | R        | G  |    |
| Distributions<br>digitized in<br>settings terms<br>of of<br>colour-mixer raw<br>scores | (Unsaturated Blue-Green) | 0            | 0     | 10            | 0     | 10       | 1  | 9        | 0  | 10 |
|                                                                                        |                          | 1            | 0     | 10            | 0     | 10       | 0  | 10       | 0  | 10 |
|                                                                                        |                          | 2            | 0     | 10            | 0     | 10       | 1  | 9        | 0  | 10 |
|                                                                                        |                          | 3            | 0     | 10            | 0     | 10       | 0  | 10       | 1  | 9  |
|                                                                                        |                          | 4            | 0     | 10            | 0     | 10       | 0  | 10       | 0  | 10 |
|                                                                                        |                          | 5            | 0     | 10            | 0     | 10       | 1  | 9        | 0  | 10 |
|                                                                                        |                          | 6            | 0     | 10            | 7     | 3        | 8  | 2        | 8  | 2  |
|                                                                                        |                          | 7            | 9     | 1             | 7     | 3        | 10 | 0        | 4  | 6  |
|                                                                                        |                          | 8            | 10    | 0             | 10    | 0        | 10 | 0        | 10 | 0  |
|                                                                                        |                          | 9            | 10    | 0             | 10    | 0        | 10 | 0        | 10 | 0  |
|                                                                                        |                          | 10           | 10    | 0             | 10    | 0        | 10 | 0        | 10 | 0  |
|                                                                                        |                          | 11           | 10    | 0             | 10    | 0        | 10 | 0        | 9  | 1  |
|                                                                                        |                          | 12           | 10    | 0             | 10    | 0        | 10 | 0        | 10 | 0  |
|                                                                                        |                          | 13           | 10    | 0             | 10    | 0        | 10 | 0        | 10 | 0  |
|                                                                                        |                          | 14           | 10    | 0             | 10    | 0        | 10 | 0        | 9  | 1  |
|                                                                                        | (Unsaturated Red)        | 15           | 10    | 0             | 10    | 0        | 10 | 0        | 10 | 0  |
| MEAN REACTION-TIME (SECS.)                                                             |                          | 1.326        |       | 1.367         |       | .577     |    | .585     |    |    |
| RTs ON VERBAL TESTS                                                                    |                          | .5           | 0     | 0             | 1     | 0        |    |          |    |    |
| INCLUDE OPERATOR'S                                                                     |                          | 1.5          | 0     | 0             | 1     | 0        |    |          |    |    |
| MONITORING TIMES                                                                       |                          | 2.5          | 0     | 0             | 1     | 1        |    |          |    |    |
| Boundaries, Distributions                                                              |                          | 3.5          | 0     | 0             | 0     | 1        |    |          |    |    |
|                                                                                        |                          | 4.5          | 0     | 0             | 1     | 0        |    |          |    |    |
| digitized in terms                                                                     |                          | 5.5          | 0     | 7             | 9     | 8        |    |          |    |    |
| settings of                                                                            |                          | 6.5          | 9     | 6             | 2     | 8        |    |          |    |    |
| of derived                                                                             |                          | 7.5          | 1     | 3             | 0     | 6        |    |          |    |    |
|                                                                                        |                          | 8.5          | 0     | 0             | 0     | 0        |    |          |    |    |
|                                                                                        |                          | 9.5          | 0     | 0             | 0     | 0        |    |          |    |    |
| colour-mixer, "achromaticness"                                                         |                          | 10.5         | 0     | 0             | 0     | 1        |    |          |    |    |
| scores                                                                                 |                          | 11.5         | 0     | 0             | 0     | 1        |    |          |    |    |
|                                                                                        |                          | 12.5         | 0     | 0             | 0     | 0        |    |          |    |    |
|                                                                                        |                          | 13.5         | 0     | 0             | 0     | 1        |    |          |    |    |
|                                                                                        |                          | 14.5         | 0     | 0             | 0     | 1        |    |          |    |    |
| Sample Sizes                                                                           |                          | 10           | 16    | 15            | 28    |          |    |          |    |    |
| Sample Means                                                                           |                          | 6.60         | 6.25  | 5.27          | 7.54  |          |    |          |    |    |
| Sample SDs                                                                             |                          | .316         | .775  | 1.791         | 2.617 |          |    |          |    |    |
| Medians, Q <sub>2</sub>                                                                |                          | 6.56         | 6.17  | 5.39          | 6.50  |          |    |          |    |    |
| First Quartiles, Q <sub>1</sub>                                                        |                          | 6.28         | 5.57  | 4.75          | 5.63  |          |    |          |    |    |
| Third Quartiles, Q <sub>3</sub>                                                        |                          | 6.83         | 6.83  | 5.81          | 7.38  |          |    |          |    |    |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub>                                   |                          | .556         | 1.262 | 1.056         | 1.725 |          |    |          |    |    |
| Mean Interquartile Range, J                                                            |                          | .909         |       | 1.390         |       |          |    |          |    |    |
| Mean Diffs. in "achr" score units                                                      |                          | -.350        |       | +2.269        |       |          |    |          |    |    |
| Mdn. Diffs. in "achr" score units                                                      |                          | -.389        |       | +1.111        |       |          |    |          |    |    |
| Mean Differences in J-units                                                            |                          | -.386        |       | +1.630        |       |          |    |          |    |    |
| Mdn. Differences in J-units                                                            |                          | -.428        |       | +1.799        |       |          |    |          |    |    |
| Mean Diff. t value                                                                     |                          | 1.352        |       | 2.995         |       |          |    |          |    |    |
| DF                                                                                     |                          | 24           |       | 41            |       |          |    |          |    |    |
| P                                                                                      |                          | .189         |       | .00464        |       |          |    |          |    |    |
| Direction                                                                              |                          | -ve          |       | +ve           |       |          |    |          |    |    |
| Median Diff. Chi-Sq.                                                                   |                          | 2.43         |       | 7.14          |       |          |    |          |    |    |
| DF                                                                                     |                          | 1            |       | 1             |       |          |    |          |    |    |
| P                                                                                      |                          | .178         |       | .00754        |       |          |    |          |    |    |
| Direction                                                                              |                          | -ve          |       | +ve           |       |          |    |          |    |    |



## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: EMILY DISTRIBUCTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY  
 15 FEB. PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE,  
 BLUE-GREEN TO RED, g(0) to r(15), CONTINGENT ON LOW TONE (280 Hz) IN LEFT EAR AND  
 HIGH TONE (390 Hz) IN RIGHT EAR RESPECTIVELY ( TRANSCRIBED DIRECTLY FROM COMPUTER  
 PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGI-  
 TIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECT-  
 ION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE = 8 ).

| PRE- OR POST-TRAINING?                               |                | PRE-TRAINING |       |       |       | POST-TRAINING |   |   |   |          |   |   |   |
|------------------------------------------------------|----------------|--------------|-------|-------|-------|---------------|---|---|---|----------|---|---|---|
| TIME PARAMETERS: TONE (PRECEDING COLOUR)             |                | 0            |       |       |       | 0             |   |   |   |          |   |   |   |
| (IN SECS.)                                           |                | .75          |       |       |       | .75           |   |   |   |          |   |   |   |
| POST-RESPONSE INTERVAL                               |                | .5           |       |       |       | .5            |   |   |   |          |   |   |   |
| MODE OF RESPONSE:                                    | KEY-PRESS WITH | VERBAL ONLY  |       |       |       | VERBAL        |   |   |   |          |   |   |   |
|                                                      | CONCOMITANT    | OR MONITORED |       |       |       | LOW HIGH      |   |   |   | LOW HIGH |   |   |   |
|                                                      | VERBALIZATIONS | BY OPERATOR  |       |       |       | R             | G | R | G | R        | G | R | G |
| (Unsaturated Blue-Green)                             |                | 0            | 0     | 8     | 0     | 8             | 0 | 8 | 0 | 8        | 0 | 8 | 0 |
|                                                      |                | 1            | 0     | 8     | 0     | 8             | 0 | 8 | 0 | 8        | 0 | 8 | 0 |
|                                                      |                | 2            | 0     | 8     | 0     | 8             | 0 | 8 | 0 | 8        | 0 | 8 | 0 |
|                                                      |                | 3            | 0     | 8     | 0     | 8             | 0 | 8 | 0 | 8        | 0 | 8 | 0 |
|                                                      |                | 4            | 0     | 8     | 0     | 8             | 0 | 8 | 0 | 8        | 0 | 8 | 0 |
|                                                      |                | 5            | 0     | 8     | 0     | 8             | 0 | 8 | 0 | 8        | 0 | 8 | 0 |
|                                                      |                | 6            | 1     | 7     | 4     | 4             | 0 | 8 | 4 | 4        | 4 | 0 | 8 |
|                                                      |                | 7            | 5     | 3     | 2     | 6             | 4 | 4 | 4 | 0        | 8 | 0 | 8 |
|                                                      |                | 8            | 7     | 1     | 7     | 1             | 5 | 3 | 8 | 0        | 0 | 0 | 0 |
|                                                      |                | 9            | 8     | 0     | 7     | 1             | 1 | 7 | 6 | 2        | 0 | 0 | 0 |
|                                                      |                | 10           | 6     | 2     | 8     | 0             | 4 | 4 | 7 | 1        | 0 | 0 | 0 |
|                                                      |                | 11           | 8     | 0     | 8     | 0             | 4 | 4 | 7 | 1        | 0 | 0 | 0 |
|                                                      |                | 12           | 8     | 0     | 8     | 0             | 8 | 0 | 8 | 0        | 0 | 0 | 0 |
|                                                      |                | 13           | 8     | 0     | 8     | 0             | 8 | 0 | 8 | 0        | 0 | 0 | 0 |
|                                                      |                | 14           | 8     | 0     | 8     | 0             | 8 | 0 | 8 | 0        | 0 | 0 | 0 |
|                                                      |                | 15           | 8     | 0     | 8     | 0             | 8 | 0 | 8 | 0        | 0 | 0 | 0 |
| (Unsaturated Red)                                    |                |              |       |       |       |               |   |   |   |          |   |   |   |
| MEAN REACTION-TIME (SECS.)                           |                | 2.495        | 2.653 | 1.629 | 1.573 |               |   |   |   |          |   |   |   |
| RTs ON VERBAL TESTS                                  |                | .5           | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
| INCLUDE OPERATOR'S                                   |                | 1.5          | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
| MONITORING TIMES                                     |                | 2.5          | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
|                                                      |                | 3.5          | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
| Boundaries, Distributions                            |                | 4.5          | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
|                                                      |                | 5.5          | 1     | 4     | 0     | 4             | 0 | 4 | 0 | 4        | 0 | 4 | 0 |
| digitized in terms                                   |                | 6.5          | 6     | 6     | 4     | 4             | 4 | 4 | 4 | 4        | 4 | 4 | 4 |
|                                                      |                | 7.5          | 4     | 7     | 7     | 8             | 7 | 8 | 7 | 8        | 7 | 8 | 7 |
| settings of                                          |                | 8.5          | 1     | 2     | 6     | 2             | 6 | 2 | 6 | 2        | 6 | 2 | 6 |
| of derived                                           |                | 9.5          | 2     | 1     | 5     | 3             | 5 | 3 | 5 | 3        | 5 | 3 | 5 |
| colour-mixer "achromaticness"                        |                | 10.5         | 2     | 0     | 4     | 2             | 4 | 2 | 4 | 2        | 4 | 2 | 4 |
|                                                      |                | 11.5         | 0     | 0     | 0     | 1             | 0 | 1 | 0 | 1        | 0 | 1 | 0 |
| scores                                               |                | 12.5         | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
|                                                      |                | 13.5         | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
|                                                      |                | 14.5         | 0     | 0     | 0     | 0             | 0 | 0 | 0 | 0        | 0 | 0 | 0 |
| Sample Sizes                                         |                | 16           | 20    | 26    | 24    |               |   |   |   |          |   |   |   |
| Sample Means                                         |                | 7.69         | 7.00  | 8.42  | 7.75  |               |   |   |   |          |   |   |   |
| Sample SDs                                           |                | 1.559        | 1.100 | 1.324 | 1.700 |               |   |   |   |          |   |   |   |
| Medians, Q <sub>2</sub>                              |                | 7.25         | 7.00  | 8.33  | 7.50  |               |   |   |   |          |   |   |   |
| First Quartiles, Q <sub>1</sub>                      |                | 6.50         | 6.17  | 7.36  | 6.50  |               |   |   |   |          |   |   |   |
| Third Quartiles, Q <sub>3</sub>                      |                | 9.00         | 7.71  | 9.52  | 9.00  |               |   |   |   |          |   |   |   |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> |                | 2.500        | 1.543 | 2.114 | 2.500 |               |   |   |   |          |   |   |   |
| Mean Interquartile Range, J                          |                | 2.024        | 2.321 |       |       |               |   |   |   |          |   |   |   |
| Mean Diffs. in "achr" score units                    |                | -.688        | -.673 |       |       |               |   |   |   |          |   |   |   |
| Mdn. Diffs. in "achr" score units                    |                | -.250        | -.833 |       |       |               |   |   |   |          |   |   |   |
| Mean Differences in J-units                          |                | -.329        | -.288 |       |       |               |   |   |   |          |   |   |   |
| Mdn. Differences in J-units                          |                | -.124        | -.359 |       |       |               |   |   |   |          |   |   |   |
| Mean Diff. t value                                   |                | 1.550        | 1.568 |       |       |               |   |   |   |          |   |   |   |
| DF                                                   |                | 34           | 48    |       |       |               |   |   |   |          |   |   |   |
| P                                                    |                | .130         | .123  |       |       |               |   |   |   |          |   |   |   |
| Direction                                            |                | -ve          | -ve   |       |       |               |   |   |   |          |   |   |   |
| Median Diff. Chi-Sq.                                 |                | .11          | 2.00  |       |       |               |   |   |   |          |   |   |   |
| DF                                                   |                | 1            | 1     |       |       |               |   |   |   |          |   |   |   |
| P                                                    |                | .740         | .157  |       |       |               |   |   |   |          |   |   |   |
| Direction                                            |                | -ve          | -ve   |       |       |               |   |   |   |          |   |   |   |

PRE- & POST-  
NETT DIFFS.

## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: TOAN  
14 FEB

DISTRIBUTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE, BLUE-GREEN TO RED, g(0) to r(15), CONTINGENT ON LOW TONE (200 Hz) IN LEFT EAR AND HIGH TONE (300 Hz) IN RIGHT EAR RESPECTIVELY (TRANSCRIBED DIRECTLY FROM COMPUTER PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE = 10).

| PRE- OR POST-TRAINING?                               |                            | PRE-TRAINING |       | POST-TRAINING |       |    |    |    |    |
|------------------------------------------------------|----------------------------|--------------|-------|---------------|-------|----|----|----|----|
| TIME PARAMETERS: TONE (PRECEDING COLOUR)             |                            | 0.5          |       | 0.5           |       |    |    |    |    |
| (IN SECS.)                                           |                            | 1.0          |       | 1.0           |       |    |    |    |    |
| POST-RESPONSE INTERVAL                               |                            | 0.5          |       | 0.5           |       |    |    |    |    |
| MODE OF RESPONSE:                                    | KEY-PRESS WITH             | VERBAL       |       | VERBAL        |       |    |    |    |    |
|                                                      | CONCOMITANT OR MONITORED   | LOW HIGH     |       | LOW HIGH      |       |    |    |    |    |
|                                                      | VERBALIZATIONS BY OPERATOR | R            | G     | R             | G     | R  | G  | R  | G  |
| (Unsaturated Blue-Green)                             |                            | 0            | 0     | 10            | 0     | 10 | 0  | 10 |    |
|                                                      |                            | 1            | 0     | 10            | 0     | 10 | 0  | 10 |    |
|                                                      |                            | 2            | 0     | 10            | 0     | 10 | 0  | 10 |    |
|                                                      |                            | 3            | 0     | 10            | 0     | 10 | 0  | 10 |    |
| Distributions                                        |                            | 4            | 0     | 10            | 0     | 10 | 0  | 10 |    |
| digitized in                                         |                            | 5            | 0     | 10            | 0     | 10 | 0  | 10 |    |
| settings terms                                       |                            | 6            | 0     | 10            | 0     | 10 | 0  | 10 |    |
| of of                                                |                            | 7            | 0     | 10            | 0     | 10 | 0  | 10 |    |
| colour-mixer raw                                     |                            | 8            | 0     | 10            | 0     | 10 | 0  | 10 |    |
| scores                                               |                            | 9            | 0     | 10            | 0     | 10 | 0  | 10 |    |
|                                                      |                            | 10           | 3     | 7             | 3     | 7  | 0  | 10 | 0  |
|                                                      |                            | 11           | 8     | 2             | 9     | 1  | 8  | 2  | 5  |
|                                                      |                            | 12           | 9     | 1             | 10    | 0  | 10 | 0  | 9  |
|                                                      |                            | 13           | 10    | 0             | 10    | 0  | 10 | 0  | 10 |
| (Unsaturated Red)                                    |                            | 14           | 10    | 0             | 10    | 0  | 10 | 0  | 10 |
|                                                      |                            | 15           | 10    | 0             | 10    | 0  | 10 | 0  | 10 |
| MEAN REACTION-TIME (SECS.)                           |                            | 2.463        | 2.437 | 1.867         | 1.858 |    |    |    |    |
| RTS ON VERBAL TESTS                                  |                            | 0.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| INCLUDE OPERATOR'S                                   |                            | 1.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| MONITORING TIMES                                     |                            | 2.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| Boundaries, Distributions                            |                            | 3.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| digitized in terms                                   |                            | 4.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| settings of                                          |                            | 5.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| of derived                                           |                            | 6.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| colour-mixer "achromaticness"                        |                            | 7.5          | 0     | 0             | 0     | 0  | 0  |    |    |
| scores                                               |                            | 8.5          | 0     | 0             | 0     | 0  | 0  |    |    |
|                                                      |                            | 9.5          | 3     | 3             | 0     | 0  | 0  |    |    |
|                                                      |                            | 10.5         | 9     | 10            | 8     | 5  |    |    |    |
|                                                      |                            | 11.5         | 3     | 1             | 2     | 6  |    |    |    |
|                                                      |                            | 12.5         | 1     | 0             | 0     | 1  |    |    |    |
|                                                      |                            | 13.5         | 0     | 0             | 0     | 0  |    |    |    |
|                                                      |                            | 14.5         | 0     | 0             | 0     | 0  |    |    |    |
| Sample Sizes                                         |                            | 16           | 14    | 10            | 12    |    |    |    |    |
| Sample Means                                         |                            | 10.63        | 10.36 | 10.7          | 11.17 |    |    |    |    |
| Sample SDs                                           |                            | 3.06         | 5.34  | 4.22          | 6.51  |    |    |    |    |
| Medians, Q <sub>2</sub>                              |                            | 10.56        | 10.40 | 9.63          | 10.17 |    |    |    |    |
| First Quartiles, Q <sub>1</sub>                      |                            | 10.11        | 10.05 | 9.31          | 9.60  |    |    |    |    |
| Third Quartiles, Q <sub>3</sub>                      |                            | 11.00        | 10.75 | 9.94          | 10.67 |    |    |    |    |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> |                            | 8.89         | 7.00  | 6.25          | 10.67 |    |    |    |    |
| Mean Interquartile Range, J                          |                            | 7.94         | 8.46  |               |       |    |    |    |    |
| Mean Diffs. in "achr" score units                    |                            | -2.68        | 4.67  |               |       |    |    |    |    |
| Mdn. Diffs. in "achr" score units                    |                            | -1.56        | 5.42  |               |       |    |    |    |    |
| Mean Differences in J-units                          |                            | -3.37        | 5.62  |               |       |    |    |    |    |
| Mdn. Differences in J-units                          |                            | -1.96        | 6.10  |               |       |    |    |    |    |
| Mean Diff. t value                                   |                            | 1.0555       | 1.947 |               |       |    |    |    |    |
| DF                                                   |                            | 28           | 20    |               |       |    |    |    |    |
| P                                                    |                            | .300         | .066  |               |       |    |    |    |    |
| Direction                                            |                            | -ve          | +ve   |               |       |    |    |    |    |
| Median Diff. Chi-Sq.                                 |                            | .13          | 1.65  |               |       |    |    |    |    |
| DF                                                   |                            | 1            | 1     |               |       |    |    |    |    |
| P                                                    |                            | .718         | .199  |               |       |    |    |    |    |
| Direction                                            |                            | -ve          | +ve   |               |       |    |    |    |    |

# CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: TESTING SESSIONS

SUBJECT: ERIC  
17 FEB

DISTRIBUTIONS OF (a) RESPONSES ('RED' OR 'GREEN') TO RANDOMLY PRESENTED DIGITIZED COLOUR-MIXER SETTINGS OF UNSATURATED RANGE, BLUE-GREEN TO RED, g(0) to r(15), CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR RESPECTIVELY ( TRANSCRIBED DIRECTLY FROM COMPUTER PRINTOUT), AND (b) OF DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 0.5 TO 14.5, AND CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF TONE-CONTINGENT DIVERGENCES. (MAXIMUM ACHROMATICNESS SCORE = 8 ).

| PRE- OR POST-TRAINING?                               |                         | POST-TRAINING |             | NO       |         |          |         |          |         |
|------------------------------------------------------|-------------------------|---------------|-------------|----------|---------|----------|---------|----------|---------|
| TIME PARAMETERS:<br>(IN SECS.)                       | TONE (PRECEDING COLOUR) | 0             |             | PRE-TEST |         |          |         |          |         |
|                                                      | TONE + COLOUR           | 1.250         |             |          |         |          |         |          |         |
|                                                      | POST-RESPONSE INTERVAL  | 0.5           |             | DONE     |         |          |         |          |         |
| MODE OF<br>RESPONSE:                                 | KEY-PRESS WITH          | VERBAL ONLY   |             | VERBAL   |         |          |         |          |         |
|                                                      | CONCOMITANT             | OR MONITORED  |             | LOW HIGH |         | LOW HIGH |         | LOW HIGH |         |
|                                                      | VERBALIZATIONS          | BY OPERATOR   |             | R G R G  | R G R G | R G R G  | R G R G | R G R G  | R G R G |
| (Unsaturated Blue-Green)                             |                         | 0             | 0 8 0 8     |          |         |          |         |          |         |
|                                                      |                         | 1             | 0 8 0 8     |          |         |          |         |          |         |
|                                                      |                         | 2             | 1 7 0 8     |          |         |          |         |          |         |
|                                                      |                         | 3             | 0 8 0 8     |          |         |          |         |          |         |
|                                                      |                         | 4             | 0 8 1 7     |          |         |          |         |          |         |
|                                                      |                         | 5             | 1 7 0 8     |          |         |          |         |          |         |
|                                                      |                         | 6             | 1 7 4 4     |          |         |          |         |          |         |
|                                                      |                         | 7             | 3 5 0 8     |          |         |          |         |          |         |
|                                                      |                         | 8             | 5 3 6 2     |          |         |          |         |          |         |
|                                                      |                         | 9             | 8 0 6 2     |          |         |          |         |          |         |
|                                                      |                         | 10            | 7 1 7 1     |          |         |          |         |          |         |
|                                                      |                         | 11            | 8 0 7 1     |          |         |          |         |          |         |
|                                                      |                         | 12            | 8 0 7 1     |          |         |          |         |          |         |
|                                                      |                         | 13            | 8 0 8 0     |          |         |          |         |          |         |
|                                                      |                         | 14            | 8 0 7 1     |          |         |          |         |          |         |
|                                                      |                         | 15            | 8 0 8 0     |          |         |          |         |          |         |
| (Unsaturated Red)                                    |                         |               |             |          |         |          |         |          |         |
| MEAN REACTION-TIME (SECS.)                           |                         |               | 0.910 1.282 |          |         |          |         |          |         |
| RTs ON VERBAL TESTS                                  |                         | 1.5           | 0 0         |          |         |          |         |          |         |
| INCLUDE OPERATOR'S                                   |                         | 1.5           | 1 0         |          |         |          |         |          |         |
| MONITORING TIMES                                     |                         | 2.5           | 1 0         |          |         |          |         |          |         |
|                                                      |                         | 3.5           | 0 1         |          |         |          |         |          |         |
| Boundaries, Distributions                            |                         | 4.5           | 1 1         |          |         |          |         |          |         |
| digitized in terms                                   |                         | 5.5           | 2 4         |          |         |          |         |          |         |
| settings of                                          |                         | 6.5           | 4 4         |          |         |          |         |          |         |
| of derived                                           |                         | 7.5           | 8 6         |          |         |          |         |          |         |
|                                                      |                         | 8.5           | 3 4         |          |         |          |         |          |         |
| colour-mixer "achromaticness"                        |                         | 9.5           | 1 3         |          |         |          |         |          |         |
| scores                                               |                         | 10.5          | 1 2         |          |         |          |         |          |         |
|                                                      |                         | 11.5          | 0 2         |          |         |          |         |          |         |
|                                                      |                         | 12.5          | 0 1         |          |         |          |         |          |         |
|                                                      |                         | 13.5          | 0 1         |          |         |          |         |          |         |
|                                                      |                         | 14.5          | 0 1         |          |         |          |         |          |         |
| Sample Sizes                                         |                         |               | 22 30       |          |         |          |         |          |         |
| Sample Means                                         |                         |               | 6.86 8.27   |          |         |          |         |          |         |
| Sample SDs                                           |                         |               | 2.060 2.648 |          |         |          |         |          |         |
| Medians, Q <sub>2</sub>                              |                         |               | 7.25 7.93   |          |         |          |         |          |         |
| First Quartiles, Q <sub>1</sub>                      |                         |               | 6.13 6.38   |          |         |          |         |          |         |
| Third Quartiles, Q <sub>3</sub>                      |                         |               | 7.94 9.83   |          |         |          |         |          |         |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> |                         |               | 1.813 3.458 |          |         |          |         |          |         |
| Mean Interquartile Range, J                          |                         |               | 2.635       |          |         |          |         |          |         |
| Mean Diffs. in "achr" score units                    |                         |               | 1.403       |          |         |          |         |          |         |
| Mdn. Diffs. in "achr" score units                    |                         |               | .583        |          |         |          |         |          |         |
| Mean Differences in J-units                          |                         |               | .537        |          |         |          |         |          |         |
| Mdn. Differences in J-units                          |                         |               | .221        |          |         |          |         |          |         |
| Mean Diff. t value                                   |                         |               | 2.067       |          |         |          |         |          |         |
| DF                                                   |                         |               | 50          |          |         |          |         |          |         |
| P                                                    |                         |               | 0.0440      |          |         |          |         |          |         |
| Direction                                            |                         |               | +ve         |          |         |          |         |          |         |
| Median Diff. Chi-Sq.                                 |                         |               | 1.17        |          |         |          |         |          |         |
| DF                                                   |                         |               | 1           |          |         |          |         |          |         |
| P                                                    |                         |               | .279        |          |         |          |         |          |         |
| Direction                                            |                         |               | +ve         |          |         |          |         |          |         |



# Appendix 7

| Time Parameters (seconds)        | Type and Ratio | FEEDBACK       |          |                |          | Neutral Range (no feedback)<br>(Specified as parameter) | Mid-point (Spec. as parameter) | Too Late OR TOO EARLY<br>Errors | ERRORS ON SATURATED CONDITION-<br>ING (non-reversed)<br>TRIALS. Low tone with Red; High tone with Green. |                   |           |                   | ERRORS ON UNSATURATED<br>CONDITIONING (non-rev-<br>ersed) TRIALS. High tone with Red; Low tone with Green. |                   |           |                   | ERRORS ON UNSATURATED<br>(reversed) TRIALS.<br>Low tone with Green; High tone with Red. |                   |           |                   | Total / errors on unsaturated<br>(incl. 'neutral' trials) | Total / errors on unsaturated<br>(incl. 'neutral' trials) |      |      |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|----------------------------------|----------------|----------------|----------|----------------|----------|---------------------------------------------------------|--------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------|-------------------|-----------|-------------------|------------------------------------------------------------------------------------------------------------|-------------------|-----------|-------------------|-----------------------------------------------------------------------------------------|-------------------|-----------|-------------------|-----------------------------------------------------------|-----------------------------------------------------------|------|------|-----|------------------------------|-----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
|                                  |                | Type and Ratio |          | Type and Ratio |          |                                                         |                                |                                 | LR errors                                                                                                | LR trials counted | HG errors | HG trials counted | LR errors                                                                                                  | LR trials counted | HG errors | HG trials counted | LR errors                                                                               | LR trials counted | HG errors | HG trials counted |                                                           |                                                           |      |      |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|                                  |                | conditioning   | reversed | conditioning   | reversed |                                                         |                                |                                 |                                                                                                          |                   |           |                   |                                                                                                            |                   |           |                   |                                                                                         |                   |           |                   |                                                           |                                                           |      |      |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 2.0 2.0        | 50             | 100      | 100            | 100      | 100                                                     | 0                              | 1                               | 24                                                                                                       | 0                 | 23        | 0                 | 20                                                                                                         | 1                 | 7         | 2                 | 22                                                                                      | 0                 | 8         | 0                 | 9                                                         | 6                                                         | 20.0 | 20.0 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 2.0 2.0        | 50             | 100      | 100            | 100      | 100                                                     | 1                              | 0                               | 24                                                                                                       | 0                 | 23        | 0                 | 22                                                                                                         | 1                 | 15        | 0                 | 11                                                                                      | 1                 | 9         | 1                 | 9                                                         | 5                                                         | 20.0 | 20.0 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.5 1.5        | 50             | 100      | 100            | 100      | 100                                                     | 6                              | 3                               | 93                                                                                                       | 0                 | 95        | 1                 | 91                                                                                                         | 5                 | 51        | 0                 | 53                                                                                      | 0                 | 34        | 3                 | 31                                                        | 9                                                         | 29.3 | 29.3 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 7                              | 2                               | 96                                                                                                       | 0                 | 98        | 1                 | 96                                                                                                         | 4                 | 47        | 0                 | 46                                                                                      | 0                 | 30        | 5                 | 29                                                        | 16                                                        | 29.7 | 29.7 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 1                              | 0                               | 97                                                                                                       | 0                 | 98        | 0                 | 96                                                                                                         | 9                 | 49        | 1                 | 49                                                                                      | 2                 | 31        | 1                 | 29                                                        | 15                                                        | 25.8 | 25.8 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 48                             | 6                               | 87                                                                                                       | 1                 | 88        | 1                 | 91                                                                                                         | 6                 | 41        | 2                 | 43                                                                                      | 2                 | 28        | 3                 | 28                                                        | 14                                                        | 24.4 | 24.4 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 3                              | 1                               | 96                                                                                                       | 0                 | 98        | 1                 | 95                                                                                                         | 4                 | 48        | 5                 | 48                                                                                      | 2                 | 30        | 3                 | 30                                                        | 16                                                        | 29.6 | 29.6 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 10                             | 3                               | 98                                                                                                       | 0                 | 96        | 1                 | 82                                                                                                         | 2                 | 71        | 0                 | 30                                                                                      | 0                 | 30        | 0                 | 28                                                        | 12                                                        | 29.6 | 29.6 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 13                             | 0                               | 98                                                                                                       | 1                 | 96        | 0                 | 80                                                                                                         | 3                 | 69        | 2                 | 36                                                                                      | 0                 | 28        | 0                 | 30                                                        | 9                                                         | 27.5 | 27.5 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 11                             | 0                               | 98                                                                                                       | 0                 | 96        | 0                 | 118                                                                                                        | 4                 | 46        | 0                 | 22                                                                                      | 0                 | 28        | 2                 | 29                                                        | 8                                                         | 27.2 | 27.2 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 8                              | 2                               | 97                                                                                                       | 0                 | 98        | 8                 | 117                                                                                                        | 7                 | 48        | 0                 | 22                                                                                      | 0                 | 29        | 2                 | 29                                                        | 8                                                         | 27.2 | 27.2 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 5                              | 1                               | 96                                                                                                       | 1                 | 97        | 0                 | 120                                                                                                        | 6                 | 47        | 0                 | 24                                                                                      | 0                 | 30        | 2                 | 29                                                        | 7                                                         | 28.1 | 28.1 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 3                              | 0                               | 98                                                                                                       | 0                 | 98        | 1                 | 118                                                                                                        | 15                | 48        | 3                 | 24                                                                                      | 0                 | 30        | 0                 | 30                                                        | 16                                                        | 25.4 | 25.4 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 7                              | 2                               | 97                                                                                                       | 0                 | 98        | 1                 | 118                                                                                                        | 16                | 48        | 2                 | 23                                                                                      | 0                 | 30        | 2                 | 29                                                        | 7                                                         | 25.4 | 25.4 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 7                              | 0                               | 96                                                                                                       | 0                 | 95        | 9                 | 119                                                                                                        | 17                | 47        | 3                 | 24                                                                                      | 0                 | 30        | 0                 | 30                                                        | 8                                                         | 25.3 | 25.3 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.00                             | 1.0 1.0        | 50             | 50       | 50             | 50       | 50                                                      | 17                             | 3                               | 98                                                                                                       | 0                 | 94        | 3                 | 115                                                                                                        | 10                | 46        | 1                 | 22                                                                                      | 0                 | 29        | 0                 | 30                                                        | 12                                                        | 25.1 | 25.1 |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Totals:                          |                |                |          |                |          |                                                         |                                |                                 | 147                                                                                                      | 24                | 1393      | 3                 | 1391                                                                                                       | 37                | 1498      | 110               | 1282                                                                                    | 1499              | 7         | 433               | 24                                                        | 429                                                       | 124  | 508  | 133 | 555                          | 160 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Trials presented: 7424           |                |                |          |                |          |                                                         |                                |                                 | % LR errors/LR counted: 1.72                                                                             |                   |           |                   |                                                                                                            |                   |           |                   |                                                                                         |                   |           |                   |                                                           |                                                           |      |      |     | % LR errors/LR counted: 1.72 |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Trials ruined: 147 (1.98%)       |                |                |          |                |          |                                                         |                                |                                 | % HG errors/HG counted: 0.22                                                                             |                   |           |                   |                                                                                                            |                   |           |                   |                                                                                         |                   |           |                   |                                                           |                                                           |      |      |     | % HG errors/HG counted: 0.22 |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Trials counted: 7277             |                |                |          |                |          |                                                         |                                |                                 | % LR errors/LR counted: 0.09                                                                             |                   |           |                   |                                                                                                            |                   |           |                   |                                                                                         |                   |           |                   |                                                           |                                                           |      |      |     | % LR errors/LR counted: 0.09 |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MISCELLANEOUS: * 128 trials each |                |                |          |                |          |                                                         |                                |                                 |                                                                                                          |                   |           |                   |                                                                                                            |                   |           |                   |                                                                                         |                   |           |                   |                                                           |                                                           |      |      |     |                              |     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

UNRECORDED: 128 trials each  
 +4" coulant discriminable reds with tone in right ear  
 BASIC STATISTICS CULLED FROM COMPUTER PRINTOUT  
 SUBJECT: STEPHEN  
 DATE: 1 FEB AND 3 FEB





| TIME<br>PARAMETERS<br>(seconds)     | FEEDBACK<br>Type and Ratio |                      |                            |                   | Neutral Range (no feedback)<br><br>(Specified as parameter) | Mid-point (Spec. as parameter) | TOO<br>LATE<br>OR<br>TOO<br>EARLY<br>ERRORS<br>ruined trials<br>total per session. | ERRORS ON SATUR-<br>ATED CONDITION-<br>ING (non-reversed)<br>TRIALS. Low tone<br>with Red; High<br>tone with Green. |           |                   |                   | ERRORS ON UNSATURATED (non-rev-<br>ersed) TRIALS. High<br>tone with Red; Low<br>tone with G., Low<br>tone with R.... |           |                   |                   | ERRORS ON SATUR-<br>ATED (reversed)<br>TRIALS. High<br>tone with Red;<br>Low tone with G....<br>High tone with R.... |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           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|           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |
|-------------------------------------|----------------------------|----------------------|----------------------------|-------------------|-------------------------------------------------------------|--------------------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------|-------------------|-------------------|----------------------------------------------------------------------------------------------------------------------|-----------|-------------------|-------------------|----------------------------------------------------------------------------------------------------------------------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|-----------|-----------|-------------------|-------------------|--------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|                                     | 'conditioning'             |                      | 'reversed'                 |                   |                                                             |                                |                                                                                    | trials                                                                                                              |           | trials            |                   | trials                                                                                                               |           | trials            |                   | trials                                                                                                               |           | trials            |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |
|                                     | +ve%                       | -ve%                 | +ve%                       | -ve%              |                                                             |                                |                                                                                    | +ve%                                                                                                                | -ve%      | +ve%              | -ve%              | +ve%                                                                                                                 | -ve%      | +ve%              | -ve%              | +ve%                                                                                                                 | -ve%      | +ve%              | -ve%              |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |                   |                   |           |           |
| Tone duration<br>(preceding colour) | Tone + Colour<br>Duration  | Feedback<br>Duration | Interval between<br>Trials | Session time, net | (minutes)                                                   |                                |                                                                                    | LR errors                                                                                                           | HG errors | LR trials counted | HG trials counted | LR errors                                                                                                            | HG errors | LR trials counted | HG trials counted | LR errors                                                                                                            | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors | LR trials counted | HG trials counted | LR errors | HG errors |

[illegible]

| TIME<br>PARAMETERS<br>(seconds) | Type and Ratio | FEEDBACK | Neutral Range (no feedback)<br>(Specified as parameter) | Mid-point (Spec. as parameter) | Total<br>trials | ERRORS ON SATURATED CONDITIONING (non-reversed) TRIALS. High tone with Red; Low tone with Green. |           |           |           | ERRORS ON UNSATURATED CONDITIONING (non-reversed) TRIALS. High tone with Red; Low tone with Green. |           |                              |           | ERRORS ON SATURATED (reversed) TRIALS. Low tone with Red; High tone with Green. |           |           |           | Total errors on unsaturated (reversed) trials (incl. neutr. trials) | Total errors on unsaturated (conditioning) trials (incl. neutr. trials) | Total errors on unsaturated (reversed) trials (incl. neutr. trials) |       |       |       |                               |  |  |  |  |  |
|---------------------------------|----------------|----------|---------------------------------------------------------|--------------------------------|-----------------|--------------------------------------------------------------------------------------------------|-----------|-----------|-----------|----------------------------------------------------------------------------------------------------|-----------|------------------------------|-----------|---------------------------------------------------------------------------------|-----------|-----------|-----------|---------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------|-------|-------|-------|-------------------------------|--|--|--|--|--|
|                                 |                |          |                                                         |                                |                 | Lr errors                                                                                        | Lg errors | Hr errors | Lr errors | Lg errors                                                                                          | Hr errors | Lr errors                    | Lg errors | Hr errors                                                                       | Lr errors | Lg errors | Hr errors |                                                                     |                                                                         |                                                                     |       |       |       |                               |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 |                                                                                                  |           |           |           |                                                                                                    |           |                              |           |                                                                                 |           |           |           |                                                                     |                                                                         |                                                                     |       |       |       |                               |  |  |  |  |  |
| 0.84                            | 1.25           | 1.25     | 1.25                                                    | 1.25                           | 1.25            | 2                                                                                                | 96        | 2         | 95        | 3                                                                                                  | 98        | 6                            | 71        | 12                                                                              | 21        | 14        | 18        | 9                                                                   | 41                                                                      | 8                                                                   | 29    | 57    | 243   | 243                           |  |  |  |  |  |
| 0.75                            | 1.25           | 1.25     | 1.25                                                    | 1.25                           | 1.25            | 0                                                                                                | 104       | 2         | 100       | 2                                                                                                  | 90        | 5                            | 79        | 1                                                                               | 24        | 2         | 23        | 3                                                                   | 44                                                                      | 4                                                                   | 32    | 41    | 92    | 92                            |  |  |  |  |  |
| 0.54                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 1                                                                                                | 103       | 2         | 97        | 3                                                                                                  | 84        | 1                            | 80        | 2                                                                               | 23        | 3         | 23        | 11                                                                  | 45                                                                      | 7                                                                   | 30    | 24    | 240   | 240                           |  |  |  |  |  |
| 0.51                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 2                                                                                                | 104       | 4         | 103       | 2                                                                                                  | 96        | 8                            | 80        | 1                                                                               | 23        | 3         | 24        | 16                                                                  | 47                                                                      | 11                                                                  | 32    | 57    | 342   | 342                           |  |  |  |  |  |
| 0.46                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 0                                                                                                | 104       | 0         | 104       | 2                                                                                                  | 96        | 6                            | 80        | 0                                                                               | 24        | 0         | 24        | 13                                                                  | 48                                                                      | 19                                                                  | 32    | 52    | 475   | 475                           |  |  |  |  |  |
| 0.44                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 4                                                                                                | 104       | 0         | 104       | 2                                                                                                  | 96        | 8                            | 80        | 0                                                                               | 24        | 0         | 24        | 16                                                                  | 48                                                                      | 18                                                                  | 32    | 51    | 425   | 425                           |  |  |  |  |  |
| 0.42                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 3                                                                                                | 104       | 1         | 102       | 1                                                                                                  | 96        | 7                            | 80        | 0                                                                               | 24        | 0         | 24        | 21                                                                  | 47                                                                      | 15                                                                  | 32    | 46    | 453   | 453                           |  |  |  |  |  |
| 0.44                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 0                                                                                                | 104       | 0         | 104       | 2                                                                                                  | 96        | 6                            | 80        | 1                                                                               | 24        | 0         | 24        | 14                                                                  | 48                                                                      | 15                                                                  | 31    | 46    | 353   | 353                           |  |  |  |  |  |
| 0.44                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 1                                                                                                | 104       | 0         | 104       | 2                                                                                                  | 96        | 4                            | 80        | 0                                                                               | 24        | 2         | 24        | 9                                                                   | 48                                                                      | 11                                                                  | 32    | 33    | 253   | 253                           |  |  |  |  |  |
| 0.46                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 1                                                                                                | 104       | 0         | 104       | 2                                                                                                  | 96        | 6                            | 80        | 0                                                                               | 24        | 0         | 24        | 10                                                                  | 47                                                                      | 11                                                                  | 32    | 70    | 266   | 266                           |  |  |  |  |  |
| 0.49                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 2                                                                                                | 104       | 3         | 104       | 3                                                                                                  | 95        | 8                            | 79        | 0                                                                               | 24        | 1         | 24        | 17                                                                  | 48                                                                      | 14                                                                  | 32    | 63    | 388   | 388                           |  |  |  |  |  |
| 0.43                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 0                                                                                                | 104       | 2         | 104       | 1                                                                                                  | 96        | 5                            | 80        | 0                                                                               | 24        | 0         | 24        | 13                                                                  | 48                                                                      | 15                                                                  | 32    | 33    | 350   | 350                           |  |  |  |  |  |
| 0.47                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 2                                                                                                | 104       | 0         | 104       | 3                                                                                                  | 95        | 10                           | 79        | 0                                                                               | 24        | 1         | 24        | 19                                                                  | 48                                                                      | 12                                                                  | 32    | 75    | 388   | 388                           |  |  |  |  |  |
| 0.47                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 0                                                                                                | 104       | 0         | 104       | 3                                                                                                  | 96        | 8                            | 80        | 0                                                                               | 24        | 0         | 24        | 14                                                                  | 48                                                                      | 10                                                                  | 32    | 62    | 350   | 350                           |  |  |  |  |  |
| 0.47                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 0                                                                                                | 104       | 1         | 104       | 2                                                                                                  | 96        | 5                            | 80        | 0                                                                               | 24        | 0         | 24        | 20                                                                  | 48                                                                      | 11                                                                  | 32    | 40    | 388   | 388                           |  |  |  |  |  |
| 0.46                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 2                                                                                                | 104       | 1         | 103       | 2                                                                                                  | 95        | 5                            | 80        | 0                                                                               | 24        | 0         | 24        | 18                                                                  | 48                                                                      | 11                                                                  | 32    | 40    | 362   | 362                           |  |  |  |  |  |
| 0.46                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 0                                                                                                | 104       | 1         | 104       | 1                                                                                                  | 96        | 7                            | 80        | 1                                                                               | 24        | 1         | 24        | 15                                                                  | 48                                                                      | 12                                                                  | 32    | 45    | 337   | 337                           |  |  |  |  |  |
| 0.46                            | 1.0            | 1.0      | 1.0                                                     | 1.0                            | 1.0             | 4                                                                                                | 104       | 0         | 102       | 2                                                                                                  | 95        | 2                            | 80        | 0                                                                               | 23        | 0         | 24        | 11                                                                  | 48                                                                      | 11                                                                  | 32    | 23    | 275   | 275                           |  |  |  |  |  |
| Totals:                         |                |          |                                                         |                                |                 | 126                                                                                              | 242071    | 202048    | 421882    | 1251588                                                                                            | 19473     | 28472                        | 28942     | 22634                                                                           | 22634     | 22634     | 22634     | 22634                                                               | 22634                                                                   | 22634                                                               | 22634 | 22634 | 22634 | 22634                         |  |  |  |  |  |
| Hours                           |                |          |                                                         |                                |                 | 6.05                                                                                             |           |           |           |                                                                                                    |           |                              |           |                                                                                 |           |           |           |                                                                     |                                                                         |                                                                     |       |       |       |                               |  |  |  |  |  |
| Trials presented: 10,240        |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
| Trials missed: 126 (1.23%)      |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
| Trials counted: 10,114          |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
| Miscellaneous:                  |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LG errors/LG counted: 2.20                                                                     |           |           |           |                                                                                                    |           | % LG errors/LG counted: 2.93 |           |                                                                                 |           |           |           | % LG errors/LG counted: 2.93                                        |                                                                         |                                                                     |       |       |       | % LG errors/LG counted: 2.93  |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % LR errors/LR counted: 1.16                                                                     |           |           |           |                                                                                                    |           | % LR errors/LR counted: 4.02 |           |                                                                                 |           |           |           | % LR errors/LR counted: 38.17                                       |                                                                         |                                                                     |       |       |       | % LR errors/LR counted: 38.17 |  |  |  |  |  |
|                                 |                |          |                                                         |                                |                 | % HG errors/HG counted: 0.96                                                                     |           |           |           |                                                                                                    |           | % HG errors/HG counted: 5.93 |           |                                                                                 |           |           |           | % HG errors/HG counted: 29.72                                       |                                                                         |                                                                     |       |       |       | % HG errors/HG counted: 29.72 |  |  |  |  |  |

| Session No. (1st trial count) | TIME PARAMETERS (seconds) |  |  |  | FEEDBACK Type and Ratio |  |  |  | Neutral Range (no feedback) (Specified as parameter) | 100 LATE OR TOO EARLY (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) (AFB) 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Trials presented: 9216

Trials ruined: 427 (4.63%)

Trials counted: 8789

MISCELLANEOUS:

CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA  
BASIC STATISTICS COLLATED FROM COMPUTER PRINTOUT

SUBJECT: JOAN  
DATE: 14 FEB

| Session No. (51, 1st trial) | Time Parameters (seconds)                                                                                 | Feedback Type and Ratio                                                                                  | Neutral Range (no feedback) (Specified as parameter)                                                  | Mid-point (Spec. as parameter)                                                                          | LATE OR EARLY ERRORS                                                                                  | ERRORS ON SATURATED CONDITIONING (non-reversed) TRIALS. High tone with Red; Low tone with Green.     |                                                                                                             |                                                                                                              |                                                                                                     | ERRORS ON SATURATED CONDITIONING (reversed) TRIALS. High tone with Red; Low tone with Green.               |                                                                                                           |                                                                                                              |                                                                                                          | ERRORS ON UNSATURATED CONDITIONING (non-reversed) TRIALS. High tone with g...., Low tone with r....          |                                                                                                             |                                                                                                                |                                                                                                            | ERRORS ON UNSATURATED CONDITIONING (reversed) TRIALS. High tone with g...., Low tone with r.... |                   |           |                   | Total % errors on unsaturated ('conditioning') trials (incl. neutral) | Total % errors on unsaturated ('reversed') trials (incl. neutral) |                   |                  |           |                   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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trials counted |                                                                       |                                                                   | neutr. rev. errs. | neutr. rev. cld. | HR errors | HR trials counted |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  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SUBJECT: EMILY  
DATE: 15 FEB

CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA  
BASIC STATISTICS CULLED FROM COMPUTER PRINTOUT

| Session No. (incl. trials run) | Time Parameters (seconds) | FEEDBACK Type and Ratio | Neutral Range (no feedback) (Specified as parameter) |        |                   |        | Mid-point (Spec. as parameter) | TOO LATE OR TOO EARLY ERROR | ERRORS ON SATURATED CONDITIONING (non-reversed) TRIALS. Low tone with Red; High tone with Green. |           |           |           | ERRORS ON UNSATURATED CONDITIONING (non-reversed) TRIALS. High tone with Red; Low tone with Green. |           |           |           | ERRORS ON (SATURATED (reversed) TRIALS. Low tone with Green; High tone with Red. |           |           |           | Total % errors on unsaturated ('conditioning') trials | Total % errors on unsaturated ('reversed') trials |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |     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|                                |                           |                         | 'conditioning' trials                                |        | 'reversed' trials |        |                                |                             | Lr errors                                                                                        | Hr errors | Lg errors | Hg errors | Lr errors                                                                                          | Hr errors | Lg errors | Hg errors | Lr errors                                                                        | Hr errors | Lg errors | Hg errors |                                                       |                                                   |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      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|                                |                           |                         | +                                                    | -      | +                 | -      |                                |                             |                                                                                                  |           |           |           |                                                                                                    |           |           |           |                                                                                  |           |           |           |                                                       |                                                   |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      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|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 1                              | 0 1.5 0                   | 1.25 0                  | 1.25 0                                               | 1.25 0 | 1.25 0            | 1.25 0 | 1.25 0                         | 1.25 0                      | 1.25 0                                                                                           | 1.25 0    | 1.25 0    | 1.25 0    | 1.25 0                                                                                             | 1.25 0    | 1.25 0    | 1.25 0    | 1.25 0                                                                           | 1.25 0    | 1.25 0    | 1.25 0    | 1.25 0                                                | 1.25 0                                            | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 | 1.25 0 |

SUBJECT: ERIC  
DATE: 17 FEB

CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA  
BASIC STATISTICS COLLATED FROM COMPUTER PRINTOUT

\* 1/2 Session (166 trials)

MISCELLANEOUS: a qualitative report

[illegible]

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: WITHIN-SESSION  
ASSESSMENT TRIALS

Contents

Stephen. Assessment trials not included in his training programme.

Stan. p.278-279

Steve. p. 280-281

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Silke. p. 284-285

Joan. p.286-287

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Mike. p.292 (Analysis not possible after 5th session)



## CONDITIONING OF TONE-CONTINGENT BLUE-RESPONSES: EXPERIMENTAL DATA

SUBJECT: STAN

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, 9(0) TO 1(15), CONTINGENT ON LOW TONE (750 HZ) IN LEFT EAR AND HIGH TONE (350 HZ) IN RIGHT EAR RESPECTIVELY (COLLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIFFERENCES.

|                                                                       |                                              |          |         |         |         |         |         |         |         |         |
|-----------------------------------------------------------------------|----------------------------------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|
| Session Number (512 trials each)                                      | 1                                            | 2        | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      |
| Neutral Range, spec. as parameter, no f/back                          | 6.7                                          | 6.7      | 6.7     | 6.7     | 6.7     | 6.7     | 6.7     | 7.8     | 7.8     | 7.8     |
| F/5 midpoint, specified as parameter                                  | 6.7                                          | 6.7      | 6.7     | 6.7     | 6.7     | 6.7     | 6.7     | 7.8     | 7.8     | 7.8     |
| Feedback Ratio & Type, spec. as parameter                             | 100% +ve                                     | 100% +ve | 50% +ve | 25% +ve | 25% +ve | 25% +ve | 25% +ve | 25% +ve | 25% +ve | 25% +ve |
| No. of ruined 'Assessment Trials', range 4-11                         | 3                                            | 1        | 0       | 0       | 0       | 2       | 2       | 1       | 1       | 1       |
| Tone (Low in Left ear, High in Right ear)                             | LOW                                          | HIGH     | LOW     | HIGH    | LOW     | HIGH    | LOW     | HIGH    | LOW     | HIGH    |
| Key-press responses, Left for R, Right for G                          | R G R G                                      | R G R G  | R G R G | R G R G | R G R G | R G R G | R G R G | R G R G | R G R G | R G R G |
| (De-saturated Blue-Green)                                             | 4                                            | 2        | 6       | 0       | 7       | 1       | 7       | 0       | 8       | 3       |
| Distributions in terms of raw scores                                  | 5                                            | 1        | 7       | 0       | 8       | 0       | 8       | 1       | 7       | 3       |
| Digitized settings of colour-mixer                                    | 6                                            | 0        | 8       | 1       | 7       | 2       | 6       | 1       | 7       | 0       |
| (De-saturated Red)                                                    | 7                                            | 3        | 5       | 3       | 5       | 1       | 7       | 5       | 3       | 6       |
|                                                                       | 8                                            | 2        | 6       | 5       | 3       | 4       | 3       | 7       | 1       | 4       |
|                                                                       | 9                                            | 3        | 5       | 7       | 0       | 7       | 1       | 6       | 2       | 7       |
|                                                                       | 10                                           | 8        | 0       | 6       | 1       | 6       | 2       | 8       | 0       | 3       |
|                                                                       | 11                                           | 8        | 0       | 5       | 3       | 7       | 0       | 8       | 0       | 7       |
|                                                                       | 12                                           | 3        | 0       | 1       | 1       | 7       | 0       | 3       | 5       | 8       |
|                                                                       | 13                                           | 0        | 1       | 2       | 3       | 5       | 0       | 3       | 1       | 5       |
|                                                                       | 14                                           | 3        | 4       | 7       | 7       | 3       | 2       | 1       | 4       | 8       |
|                                                                       | 15                                           | 5        | 8       | 7       | 2       | 6       | 0       | 8       | 2       | 0       |
|                                                                       | 16                                           | 5        | 3       | 6       | 0       | 8       | 0       | 7       | 0       | 8       |
| Boundaries, digitized settings of colour-mixer (Max. achr. score = 8) | 4.5                                          | 5.5      | 6.5     | 7.5     | 8.5     | 9.5     | 10.5    | 11.5    | 12.5    | 13.5    |
| Distributions in terms of raw scores                                  | 3                                            | 0        | 1       | 1       | 7       | 0       | 7       | 2       | 1       | 0       |
| Sample Sizes                                                          | 22                                           | 21       | 20      | 20      | 33      | 29      | 14      | 32      | 24      | 33      |
|                                                                       | Means                                        | 7.55     | 8.02    | 7.80    | 7.05    | 6.59    | 8.12    | 5.43    | 8.56    | 6.13    |
|                                                                       | Medians                                      | 7.60     | 7.69    | 7.20    | 6.26    | 6.64    | 8.75    | 5.00    | 8.75    | 6.00    |
|                                                                       | First Quartiles                              | 6.50     | 7.31    | 6.67    | 6.14    | 5.25    | 7.61    | 4.50    | 7.67    | 4.86    |
|                                                                       | Third Quartiles                              | 8.90     | 8.92    | 7.00    | 8.00    | 7.82    | 9.72    | 6.25    | 9.86    | 7.33    |
|                                                                       | Interquartile Ranges, Q2-Q1                  | 2.40     | 1.61    | 2.33    | 1.86    | 2.57    | 2.11    | 1.75    | 2.19    | 2.48    |
|                                                                       | Mean Interquartile Range, J                  | 2.003    | 2.095   | 2.341   | 1.970   | 2.530   | 2.345   | 1.704   | 2.819   | 2.583   |
|                                                                       | Mean Differences (H-L) in Achr-score units   | .478     | -.750   | 2.185   | 3.134   | 2.345   | .619    | .994    | 1.759   | 1.945   |
|                                                                       | Median Differences (H-L) in Achr-score units | .098     | -.943   | 2.107   | 3.750   | 2.750   | .261    | .857    | 2.171   | 2.083   |
|                                                                       | Mean Differences in J units                  | .239     | -.350   | .933    | 1.591   | .927    | .363    | .353    | .681    | .748    |
| Median Differences in J units                                         | .044                                         | -.450    | .900    | 1.904   | 1.087   | .153    | .304    | .841    | .801    |         |







SUBJECT: NEVIL

## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, 9(0) TO 1(15), CONTINGENT ON LOW TONE (250 Hz) IN LEFT EAR AND HIGH TONE (350 Hz) IN RIGHT EAR RESPECTIVELY (CULLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIVERGENCES.

| Session Number (512 trials each)              | 1        | 2        | 3        | 4        | 5       | 6       | 7       | 8        | 9        | 10       |
|-----------------------------------------------|----------|----------|----------|----------|---------|---------|---------|----------|----------|----------|
| Neutral Range, spec. as parameter, no f/back  | —        | —        | —        | —        | —       | —       | —       | —        | —        | —        |
| P/3 Midpoint, specified as parameter          | 6/7      | 6/7      | 6/7      | 6/7      | 6/7     | 6/7     | 6/7     | 6/7      | 6/7      | 6/7      |
| Feedback Ratio & Type, spec. as parameter     | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 50% +ve | 50% +ve | 50% +ve | 100% +ve | 100% +ve | 100% +ve |
| 1/3 of Ruined 'Assessment Trials', range 4-11 | 4        | 5        | 5        | 5        | 8       | 7       | 2       | 7        | 2        | 1        |
| Tone (Low in Left ear, High in Right ear)     | LOW      | HIGH     | LOW      | HIGH     | LOW     | HIGH    | LOW     | HIGH     | LOW      | HIGH     |
| Key-press responses, Left for R, Right for G  | R G      | R G      | R G      | R G      | R G     | R G     | R G     | R G      | R G      | R G      |
| (De-saturated Blue-Green)                     | 4        | 1        | 7        | 0        | 8       | 0       | 8       | 0        | 8        | 0        |
| Distributions                                 | 5        | 0        | 8        | 0        | 8       | 0       | 8       | 0        | 8        | 0        |
| in                                            | 6        | 2        | 6        | 0        | 7       | 1       | 5       | 2        | 6        | 5        |
| terms                                         | 7        | 4        | 3        | 5        | 4       | 3       | 6       | 0        | 3        | 5        |
| of                                            | 8        | 0        | 7        | 0        | 8       | 0       | 7       | 1        | 7        | 1        |
| raw                                           | 9        | 8        | 0        | 7        | 1       | 8       | 0       | 7        | 1        | 8        |
| scores                                        | 10       | 7        | 0        | 7        | 1       | 8       | 0       | 7        | 1        | 8        |
| (De-saturated Red)                            | 11       | 8        | 0        | 7        | 1       | 8       | 0       | 7        | 1        | 8        |
| Distributions                                 | 4.5      | 1        | 0        | 0        | 0       | 0       | 0       | 0        | 0        | 0        |
| in                                            | 5.5      | 2        | 0        | 0        | 0       | 0       | 0       | 0        | 0        | 0        |
| terms                                         | 6.5      | 6        | 5        | 4        | 3       | 1       | 5       | 0        | 1        | 2        |
| of                                            | 7.5      | 3        | 5        | 3        | 6       | 1       | 3       | 2        | 0        | 1        |
| derived                                       | 8.5      | 0        | 1        | 0        | 1       | 2       | 0       | 0        | 0        | 0        |
| 'achromatichness'                             | 9.5      | 0        | 2        | 0        | 0       | 1       | 3       | 0        | 0        | 0        |
| scores                                        | 10.5     | 0        | 2        | 0        | 0       | 1       | 2       | 0        | 0        | 0        |
| Sample Sizes                                  | 12       | 17       | 7        | 11       | 10      | 11      | 15      | 12       | 10       | 15       |
| Means                                         | 6.42     | 7.62     | 6.93     | 7.14     | 7.00    | 7.59    | 6.70    | 7.33     | 6.30     | 7.57     |
| Medians, Q2                                   | 6.50     | 7.30     | 6.88     | 7.25     | 6.83    | 7.50    | 6.64    | 6.83     | 6.25     | 7.42     |
| First Quartiles, Q1                           | 6.00     | 6.45     | 6.44     | 6.58     | 6.42    | 7.11    | 6.11    | 6.33     | 5.50     | 6.69     |
| Third Quartiles, Q3                           | 7.00     | 8.75     | 7.42     | 7.76     | 7.50    | 7.89    | 7.31    | 7.67     | 8.13     | 8.25     |
| Interquartile Ranges, Q3-Q1                   | 1.00     | 2.30     | .98      | 1.17     | 1.08    | .78     | 1.21    | 1.33     | 1.44     | 2.10     |
| Mean Interquartile Range, J                   | 1.650    | 1.077    | .934     | 1.269    | 1.406   | 2.683   | .875    | 1.142    | 1.308    | 1.663    |
| Mean Differences (H-L) in Ach-score units     | 1.201    | .208     | .591     | .633     | 1.267   | 1.045   | .417    | .930     | .311     | .191     |
| Median Differences (H-L) in Ach-score units   | .800     | .375     | .667     | .191     | 1.167   | 1.417   | .333    | .529     | .500     | .241     |
| Mean Differences in J units                   | .728     | .193     | .633     | .499     | .901    | .390    | .476    | .814     | .420     | .115     |
| Median Differences in J units                 | .485     | .348     | .714     | .150     | .830    | .520    | .381    | .463     | .262     | .145     |



## SUBJECT: SILKE

## CONDITIONING OF TONE-CONTINGENT RESPONSES: EXPERIMENTAL DATA

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS, 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, 8(0) TO 7(15), CONTINGENT ON LOW TONE (200 Hz) IN LEFT EAR AND HIGH TONE (350 Hz) IN RIGHT EAR RESPECTIVELY (COLLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHRONATIONNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS OBTAINING TONE-CONTINGENT DIFFERENCES.

| Session Number (512 trials each)              | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|-----------------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Neutral Range, Spec. as Parameter, no f/cack  | —        | —        | —        | —        | —        | —        | —        | —        | —        | —        |
| R/S Midpoint, Specified as Parameter          | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      |
| Feedback Ratio & Type, Spec. as Parameter     | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve |
| No. of ruined 'Assessment Trials', range 4-11 | 10       | 6        | 5        | 0        | 1        | 0        | 0        | 0        | 0        | 0        |
| Tone (Low in Left ear, High in Right ear)     | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      |
| Key-press responses, Left for R, Right for G  | R        | G        | R        | G        | R        | G        | R        | G        | R        | G        |
| (De-saturated Blue-Green)                     | 4        | 2        | 6        | 1        | 7        | 0        | 8        | 3        | 5        | 0        |
| Distributions                                 | 5        | 0        | 8        | 3        | 5        | 0        | 8        | 3        | 5        | 0        |
| in                                            | 6        | 1        | 6        | 0        | 8        | 1        | 7        | 0        | 8        | 1        |
| terms                                         | 7        | 3        | 3        | 0        | 8        | 0        | 8        | 0        | 8        | 0        |
| of                                            | 8        | 3        | 3        | 0        | 8        | 0        | 8        | 0        | 8        | 0        |
| colour-mixer                                  | 9        | 3        | 4        | 0        | 7        | 3        | 5        | 2        | 6        | 4        |
| raw                                           | 10       | 5        | 2        | 3        | 4        | 6        | 1        | 6        | 2        | 8        |
| scores                                        | 11       | 8        | 0        | 6        | 2        | 8        | 0        | 8        | 0        | 8        |
| (De-saturated Red)                            | 1        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| Distributions                                 | 2        | 1        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| Boundaries, in                                | 4.5      | 5.5      | 6.5      | 7.5      | 8.5      | 9.5      | 10.5     | 11.5     | 12.5     | 13.5     |
| digitized settings                            | 5.5      | 6.5      | 7.5      | 8.5      | 9.5      | 10.5     | 11.5     | 12.5     | 13.5     | 14.5     |
| of                                            | 6.5      | 7.5      | 8.5      | 9.5      | 10.5     | 11.5     | 12.5     | 13.5     | 14.5     | 15.5     |
| colour-mixer                                  | 7.5      | 8.5      | 9.5      | 10.5     | 11.5     | 12.5     | 13.5     | 14.5     | 15.5     | 16.5     |
| (Max. achr. score                             | 8.5      | 9.5      | 10.5     | 11.5     | 12.5     | 13.5     | 14.5     | 15.5     | 16.5     | 17.5     |
| = 8)                                          | 9.5      | 10.5     | 11.5     | 12.5     | 13.5     | 14.5     | 15.5     | 16.5     | 17.5     | 18.5     |
| scores                                        | 10.5     | 11.5     | 12.5     | 13.5     | 14.5     | 15.5     | 16.5     | 17.5     | 18.5     | 19.5     |
| Sample Sizes                                  | 24       | 12       | 10       | 14       | 17       | 17       | 17       | 17       | 17       | 17       |
| Means                                         | 7.58     | 9.08     | 8.30     | 8.71     | 6.97     | 8.91     | 7.33     | 9.25     | 7.57     | 8.98     |
| Medians, Q2                                   | 7.71     | 9.40     | 8.33     | 8.63     | 7.30     | 8.79     | 7.50     | 9.20     | 7.75     | 9.42     |
| First Quartiles, Q1                           | 6.75     | 8.67     | 7.83     | 8.19     | 5.25     | 8.18     | 5.55     | 8.43     | 6.25     | 8.31     |
| Third Quartiles, Q3                           | 8.67     | 10.00    | 8.75     | 9.17     | 8.19     | 9.69     | 9.04     | 10.17    | 8.19     | 10.25    |
| Interquartile Ranges, Q3-Q1                   | 1.92     | 1.33     | .92      | .98      | 2.94     | 1.51     | 3.49     | 1.74     | 2.16     | 1.94     |
| Mean Interquartile Range, J                   | 1.625    | 0.948    | 2.423    | 2.612    | 2.050    | 1.943    | 2.25     | 1.64     | 2.278    | 1.631    |
| Mean Differences (H-L) in Ach-score units     | 1.500    | .414     | 1.941    | 1.921    | 1.410    | 1.280    | 1.440    | 2.355    | 1.914    | 1.035    |
| Median Differences (H-L) in Ach-score units   | 1.686    | .292     | 1.486    | 1.700    | 1.667    | 1.167    | 1.274    | 2.543    | 1.438    | .741     |
| Mean Differences in J units                   | .923     | .437     | .873     | .736     | .688     | .659     | .883     | 1.034    | .957     | .511     |
| Median Differences in J units                 | 1.037    | .308     | .668     | .651     | .813     | .600     | .781     | 1.116    | .719     | .366     |



## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

## SUBJECT: SILKE (CONTD)

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, 6(0) TO 1(15), CONTINGENT ON LOW TONE (250 HZ) IN LEFT EAR AND HIGH TONE (350 HZ) IN RIGHT EAR RESPECTIVELY (CULLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHRONATNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIVERGENCES.

| Session Number (512 trials each)                                         | 11       | 12       | 13       | 14       | 15       | 16       | 17       | 18       | 19       | 20       |
|--------------------------------------------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Neutral Range, spec. as parameter, no f/back                             | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      | 8/9      |
| B/S Midpoint, specified as parameter                                     | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve | 100% -ve |
| Feedback Ratio & Type, spec. as parameter                                | 1        | 0        | 1        | 1        | 1        | 0        | 0        | 0        | 0        | 0        |
| No. of ruined 'Assessment Trials', range 4-11                            | LOW      | HIGH     | LOW      | HIGH     | LOW      | HIGH     | LOW      | HIGH     | LOW      | HIGH     |
| Tone (Low in Left ear, High in Right ear)                                | R        | G        | R        | G        | R        | G        | R        | G        | R        | G        |
| Key-press responses, Left for R, Right for G                             | R        | G        | R        | G        | R        | G        | R        | G        | R        | G        |
| (De-saturated Blue-Green)                                                | 4        | 0        | 8        | 0        | 8        | 1        | 7        | 0        | 8        | 2        |
| Distributions                                                            | 5        | 0        | 7        | 0        | 8        | 1        | 7        | 0        | 8        | 2        |
| in                                                                       | 6        | 0        | 8        | 0        | 8        | 1        | 7        | 0        | 8        | 2        |
| terms                                                                    | 7        | 2        | 6        | 0        | 8        | 0        | 8        | 0        | 8        | 2        |
| of                                                                       | 8        | 4        | 4        | 2        | 6        | 4        | 4        | 2        | 6        | 4        |
| raw                                                                      | 9        | 4        | 4        | 6        | 2        | 4        | 4        | 6        | 2        | 4        |
| scores                                                                   | 10       | 4        | 4        | 6        | 2        | 4        | 4        | 6        | 2        | 4        |
| (De-saturated Red)                                                       | 11       | 8        | 0        | 5        | 3        | 8        | 0        | 5        | 3        | 8        |
| Boundaries, in digitized settings of colour-mixer (Max. achr. score = 8) | 4.5      | 0        | 0        | 2        | 0        | 3        | 0        | 0        | 2        | 0        |
|                                                                          | 5.5      | 0        | 0        | 2        | 0        | 3        | 0        | 0        | 2        | 0        |
|                                                                          | 6.5      | 2        | 0        | 1        | 0        | 0        | 4        | 0        | 2        | 0        |
|                                                                          | 7.5      | 6        | 2        | 4        | 2        | 5        | 2        | 7        | 1        | 5        |
|                                                                          | 8.5      | 8        | 8        | 8        | 7        | 7        | 6        | 4        | 8        | 5        |
|                                                                          | 9.5      | 8        | 4        | 5        | 4        | 6        | 4        | 3        | 6        | 2        |
|                                                                          | 10.5     | 4        | 5        | 1        | 5        | 3        | 5        | 2        | 4        | 0        |
| Sample Sizes                                                             | 28       | 19       | 23       | 19       | 23       | 19       | 23       | 19       | 23       | 19       |
| Means                                                                    | 2.71     | 9.13     | 6.13     | 7.79     | 9.37     | 7.45     | 9.50     | 7.87     | 8.20     | 7.91     |
| Medians, Q2                                                              | 2.75     | 8.94     | 8.31     | 8.44     | 8.07     | 9.42     | 8.14     | 9.57     | 7.93     | 9.00     |
| First Quartiles, Q1                                                      | 7.83     | 8.33     | 7.70     | 8.33     | 6.44     | 8.54     | 5.50     | 8.88     | 6.55     | 8.17     |
| Third Quartiles, Q3                                                      | 9.63     | 10.50    | 9.50     | 10.50    | 9.21     | 10.28    | 8.86     | 10.25    | 9.32     | 10.00    |
| Interquartile Ranges, Q3-Q1                                              | 1.79     | 2.17     | 1.80     | 2.17     | 2.77     | 1.75     | 3.36     | 1.38     | 2.77     | 1.83     |
| Mean Interquartile Range, J                                              | 1.979    | 1.985    | 2.258    | 2.366    | 2.302    | 2.059    | 1.932    | 2.429    | 1.854    | 1.792    |
| Mean Differences (H-L) in Ach-score units                                | .417     | 1.197    | 1.579    | 2.050    | .929     | 1.259    | 1.832    | 2.037    | 1.482    | 1.900    |
| Median Differences (H-L) in Ach-score units                              | .188     | .626     | 1.345    | 1.429    | 1.071    | .786     | 2.417    | 1.667    | 1.292    | 1.500    |
| Mean Differences in J units                                              | .211     | .603     | .699     | .866     | .433     | .612     | .948     | .839     | .799     | 1.059    |
| Median Differences in J units                                            | .095     | .315     | .596     | .604     | .465     | .382     | 1.251    | .686     | .697     | .837     |



## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, 4(10) TO 1(15), CONTINGENT ON LOW TONE (250 HZ) IN LEFT EAR AND HIGH TONE (350 HZ) IN RIGHT EAR RESPECTIVELY (CULLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHROMATICITY' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIFFERENCES.

SUBJECT: JOAN \* slight L/R  
9908010

| Session Number (512 trials each)                                        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|-------------------------------------------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Neutral Range, spec. as parameter, no f/back                            | —        | —        | —        | —        | —        | —        | —        | —        | —        | —        |
| P/3 Micropoint, spec. as parameter                                      | 9/10     | 9/10     | 9/10     | 9/10     | 9/10     | 9/10     | 9/10     | 9/10     | 9/10     | 9/10     |
| Feedback Ratio & Type, spec. as parameter                               | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve |
| No. of Pined 'Assessment Trials', range 4-11                            | 4-11     | 10       | 16       | 11       | 10       | 16       | 6        | 9        | 11       | 5        |
| Tone (Low in Left ear, High in Right ear)                               | LOW      | HIGH     | LOW      | HIGH     | LOW      | HIGH     | LOW      | HIGH     | LOW      | HIGH     |
| Key-press responses, Left for R, Right for G                            | A G A G  | A G A G  | A G A G  | A G A G  | A G A G  | A G A G  | A G A G  | A G A G  | A G A G  | A G A G  |
| (De-saturated Blue-Green)                                               | 4        | 0 7 0 4  | 2 6 0 8  | 1 4 0 7  | 0 8 0 7  | 0 6 0 8  | 1 5 0 5  | 2 6 0 8  | 1 6 0 7  | 0 7 0 7  |
| Distributions                                                           | 5        | 1 3 0 7  | 0 8 0 8  | 0 7 0 5  | 0 8 0 8  | 0 8 0 8  | 3 4 0 7  | 4 3 0 8  | 1 6 1 7  | 0 5 0 7  |
| in                                                                      | 6        | 2 4 0 5  | 1 5 0 7  | 1 7 0 7  | 0 8 0 8  | 0 6 0 7  | 2 4 2 5  | 1 1 5 4  | 3 2 4 4  | 0 6 1 6  |
| terms                                                                   | 7        | 3 4 0 5  | 1 5 0 7  | 1 7 0 5  | 0 6 0 8  | 1 6 0 7  | 3 4 0 8  | 5 2 2 6  | 5 3 2 5  | 2 6 1 6  |
| of                                                                      | 8        | 1 5 1 4  | 5 3 1 4  | 5 3 1 6  | 2 1 7 4  | 1 4 1 6  | 5 2 3 3  | 8 0 6 1  | 5 2 2 6  | 2 3 1 7  |
| raw                                                                     | 9        | 5 0 1 3  | 4 2 0 8  | 6 2 2 3  | 4 4 2 4  | 6 2 4 4  | 7 1 7 0  | 8 0 6 1  | 6 1 3 5  | 7 0 5 2  |
| scores                                                                  | 10       | 3 2 2 4  | 6 2 3 5  | 8 0 4 3  | 5 2 4 5  | 2 4 3 5  | 4 4 7 0  | 7 0 8 0  | 5 3 7 1  | 8 0 5 3  |
| (De-saturated Red)                                                      | 11       | 5 2 2 2  | 7 1 3 5  | 8 0 4 3  | 6 1 3 2  | 8 0 4 3  | 8 0 6 2  | 8 0 7 1  | 8 0 5 2  | 8 0 7 1  |
| Boundaries, in digitized settings of colour-mixer (Max.achr. score = 8) | 4.5      | 1 0 2 0  | 1 0 1 0  | 0 0 0 0  | 0 0 0 0  | 0 0 0 0  | 4 0 5 2  | 0 6 0 3  | 1 1 0 0  | 0 0 0 0  |
|                                                                         | 5.5      | 3 0 1 0  | 1 0 1 0  | 0 0 0 0  | 0 0 0 0  | 0 0 0 0  | 5 2 2 3  | 4 0 5 2  | 0 6 0 3  | 1 1 0 0  |
|                                                                         | 6.5      | 5 0 2 0  | 2 0 2 0  | 0 0 0 0  | 0 0 0 0  | 0 0 0 0  | 6 3 3 2  | 5 4 0 5  | 2 7 0 5  | 3 0 1 1  |
|                                                                         | 7.5      | 4 1 6 1  | 1 6 1 6  | 1 6 1 6  | 1 6 1 6  | 1 6 1 6  | 7 3 3 0  | 6 4 0 8  | 4 8 2 7  | 5 3 2 3  |
|                                                                         | 8.5      | 5 2 5 1  | 5 1 5 3  | 6 3 6 3  | 6 3 6 3  | 6 3 6 3  | 8 8 5 3  | 7 0 5 2  | 7 5 2 7  | 5 3 2 3  |
|                                                                         | 9.5      | 2 3 4 3  | 4 3 4 3  | 5 5 5 5  | 6 6 6 6  | 6 6 6 6  | 1 0 0 0  | 1 0 0 0  | 1 0 0 0  | 1 0 0 0  |
|                                                                         | 10.5     | 4 6 3 6  | 3 6 3 6  | 0 6 0 6  | 3 5 2 7  | 0 2 7 0  | 2 0 2 0  | 2 0 2 0  | 2 0 2 0  | 2 0 2 0  |
| Sample Sizes                                                            | 24       | 12       | 23       | 11       | 17       | 15       | 21       | 15       | 21       | 18       |
| Means                                                                   | 7.79     | 9.67     | 8.02     | 9.77     | 7.61     | 4.57     | 8.78     | 9.50     | 8.34     | 9.50     |
| Medians, Q2                                                             | 7.75     | 10.00    | 8.10     | 10.08    | 7.75     | 4.70     | 8.75     | 9.58     | 8.58     | 9.56     |
| First Quartiles, Q1                                                     | 6.40     | 9.00     | 7.13     | 9.25     | 7.04     | 8.92     | 7.88     | 8.92     | 7.75     | 8.85     |
| Third Quartiles, Q3                                                     | 9.00     | 10.50    | 9.31     | 10.54    | 8.55     | 10.38    | 9.63     | 10.25    | 9.56     | 10.25    |
| Interquartile Ranges, Q3-Q1                                             | 2.60     | 1.50     | 2.19     | 1.29     | 1.51     | 1.46     | 1.75     | 1.33     | 1.81     | 1.40     |
| Mean Interquartile Range, J                                             | 2.050    | 1.740    | 1.483    | 1.542    | 1.606    | 2.217    | 1.905    | 2.546    | 1.633    | 2.003    |
| Mean Differences (H-L) in Achr-score units                              | 1.880    | 1.750    | 1.960    | .720     | 1.160    | 1.162    | 2.775    | 1.102    | 2.044    | 1.000    |
| Median Differences (H-L) in Achr-score units                            | 2.250    | 1.983    | 1.950    | .833     | .979     | 1.067    | 2.911    | 1.450    | 1.869    | 1.300    |
| Mean Differences in J units                                             | .918     | 1.006    | 1.320    | .466     | .720     | .524     | 1.455    | .433     | 1.250    | .498     |
| Median Differences in J units                                           | 1.098    | 1.140    | 1.315    | .540     | .610     | .481     | 1.530    | .570     | 1.145    | .647     |



## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

SUBJECT: EMILY

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH '1' OF UNSATURATED RANGE, BLUE-GREEN TO RED, S(0) TO R(15), CONTINGENT ON LOW TONE (250 Hz) IN LEFT EAR AND HIGH TONE (350 Hz) IN RIGHT EAR RESPECTIVELY (COLLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHRONATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIFFERENCES.

| Session Number (542 trials each)                                      |                                             | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|-----------------------------------------------------------------------|---------------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Neutral Range, spec. as parameter, no f/back                          | 6+7                                         | 6+7      | 6+7      | 6+7      | 6+7      | 6+7      | 6+7      | 6+7      | 6+7      | 6+7      | 6+7      |
|                                                                       | 6/7                                         | 6/7      | 6/7      | 6/7      | 6/7      | 6/7      | 6/7      | 6/7      | 6/7      | 6/7      | 6/7      |
| P/3 u: point, specified as parameter                                  | 100% +ve                                    | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve | 100% +ve |
|                                                                       | 14                                          | 14       | 14       | 14       | 14       | 14       | 14       | 14       | 14       | 14       | 14       |
| Feedback Ratio & Type, spec. as parameter                             | 50% +ve                                     | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  | 50% +ve  |
|                                                                       | 7                                           | 7        | 7        | 7        | 7        | 7        | 7        | 7        | 7        | 7        | 7        |
| No. of ruined 'Assessment Trials', range 4-11                         | LOW                                         | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      |
|                                                                       | HIGH                                        | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     |
| Tone (Low in Left ear, High in Right ear)                             | R                                           | G        | R        | G        | R        | G        | R        | G        | R        | G        | R        |
|                                                                       | G                                           | R        | G        | R        | G        | R        | G        | R        | G        | R        | G        |
| Key-press responses, Left for R, Right for G                          | 4                                           | 3        | 4        | 0        | 6        | 1        | 7        | 1        | 6        | 2        | 6        |
|                                                                       | 5                                           | 5        | 2        | 1        | 4        | 3        | 2        | 6        | 4        | 2        | 1        |
| (De-saturated Blue-Green)                                             | 6                                           | 5        | 1        | 0        | 7        | 6        | 2        | 1        | 7        | 0        | 8        |
|                                                                       | 7                                           | 5        | 2        | 0        | 7        | 5        | 6        | 2        | 1        | 7        | 0        |
| Distributions in                                                      | 8                                           | 4        | 3        | 2        | 5        | 6        | 2        | 3        | 7        | 1        | 5        |
|                                                                       | 9                                           | 7        | 1        | 2        | 5        | 6        | 2        | 3        | 7        | 1        | 5        |
| Digitized settings of colour-mixer                                    | 10                                          | 6        | 2        | 6        | 2        | 7        | 1        | 8        | 0        | 6        | 2        |
|                                                                       | 11                                          | 8        | 0        | 4        | 3        | 8        | 0        | 7        | 1        | 8        | 0        |
| scores (De-saturated Red)                                             | LOW                                         | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      | LOW      |
|                                                                       | HIGH                                        | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     | HIGH     |
| Boundaries, digitized settings of colour-mixer (Max. achr. score = 6) | 4.5                                         | 6        | 1        | 5        | 3        | 6        | 1        | 6        | 2        | 2        | 4        |
|                                                                       | 5.5                                         | 3        | 1        | 5        | 4        | 4        | 2        | 2        | 4        | 3        | 1        |
| Sample Sizes                                                          | 6.5                                         | 3        | 0        | 5        | 3        | 4        | 3        | 1        | 2        | 5        | 3        |
|                                                                       | 7.5                                         | 5        | 2        | 5        | 4        | 3        | 7        | 2        | 4        | 5        | 3        |
| 'achronaticness' scores                                               | 8.5                                         | 4        | 4        | 4        | 4        | 1        | 4        | 2        | 7        | 2        | 8        |
|                                                                       | 9.5                                         | 3        | 7        | 3        | 2        | 0        | 4        | 4        | 5        | 1        | 8        |
| Means                                                                 | 10.5                                        | 2        | 5        | 1        | 2        | 0        | 4        | 3        | 6        | 0        | 6        |
|                                                                       | Means                                       | 2.6      | 2.0      | 2.8      | 2.2      | 1.8      | 2.5      | 2.0      | 2.4      | 2.5      | 3.4      |
| Medians                                                               | Medians                                     | 7.02     | 8.90     | 6.39     | 7.23     | 5.89     | 8.06     | 7.30     | 8.88     | 6.18     | 8.35     |
|                                                                       | First Quartiles                             | 7.20     | 9.29     | 6.80     | 7.25     | 5.75     | 7.93     | 7.50     | 8.86     | 5.93     | 8.63     |
| Third Quartiles                                                       | Third Quartiles                             | 5.17     | 8.25     | 5.40     | 5.63     | 4.75     | 7.04     | 4.83     | 8.00     | 5.04     | 7.30     |
|                                                                       | Interquartile Ranges                        | 8.63     | 10.00    | 8.25     | 8.63     | 6.58     | 9.44     | 9.50     | 10.00    | 7.19     | 9.69     |
| Mean Interquartile Range                                              | Mean Interquartile Range                    | 3.46     | 1.75     | 2.85     | 3.00     | 2.13     | 2.40     | 4.67     | 2.00     | 2.15     | 2.39     |
|                                                                       | Median Interquartile Range                  | 2.604    | 2.925    | 2.263    | 3.333    | 2.270    | 2.173    | 3.250    | 2.800    | 2.400    | 2.43     |
| Mean Differences (H-L) in Ach-score units                             | Mean Differences (H-L) in Ach-score units   | 1.823    | 3.34     | 2.171    | 1.575    | 2.173    | 1.142    | 2.597    | 2.726    | 2.24     | 3.21     |
|                                                                       | Median Differences (H-L) in Ach-score units | 2.086    | 4.50     | 2.179    | 1.357    | 2.696    | 1.050    | 2.583    | 2.769    | 2.24     | 3.21     |
| Mean Differences in J units                                           | Mean Differences in J units                 | 7.00     | 1.14     | .959     | .473     | .957     | .044     | .423     | .769     | .232     | .334     |
|                                                                       | Median Differences in J units               | 8.00     | 1.54     | .963     | .407     | 1.188    | .192     | .345     | .404     | .948     | .334     |



## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

SUBJECT: ERIC  
a qualitative report

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, 600 TO 1000 Hz, CONTINGENT ON LOW TONE (200 Hz) IN LEFT EAR AND HIGH TONE (330 Hz) IN RIGHT EAR RESPECTIVELY (CULLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHROMATICNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIVERGENCES.

| Session Number (512 trials each)                                        | 1           | 2           | 3           | 4           | 5           | 6           | 7           | 8*          | 9           | 10          |
|-------------------------------------------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Neutral Range, spec. as parameter, no f/back                            | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     | 6.7.8.9     |
| R/G midpoint, specified as parameter                                    | 7/8         | 7/8         | 7/8         | 7/8         | 7/8         | 7/8         | 7/8         | 7/8         | 7/8         | 7/8         |
| Feedback Ratio & Type, spec. as parameter                               | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    | 100% -ve    |
| No. of paired 'Assessment Trials', range 4-11                           | 1           | 3           | 14          | 2           | 10          | 6           | 2           | 10          | 6           | 1           |
| Tone (Low in Left ear, High in Right ear)                               | LOW         | LOW         | LOW         | LOW         | LOW         | LOW         | LOW         | LOW         | LOW         | LOW         |
| Key-press responses, Left for R, Right for G                            | R G R G R G | R G R G R G | R G R G R G | R G R G R G | R G R G R G | R G R G R G | R G R G R G | R G R G R G | R G R G R G | R G R G R G |
| (De-saturated Blue-Green) Distributions                                 | 4           | 5           | 6           | 7           | 8           | 9           | 10          | 11          | 12          | 13          |
| Digitized settings of colour-mixer raw scores (De-saturated Red)        | 1.6         | 1.7         | 1.8         | 1.9         | 2.0         | 2.1         | 2.2         | 2.3         | 2.4         | 2.5         |
| Boundaries, in digitized settings of colour-mixer (Max.achr. score = 8) | 3           | 1           | 2           | 0           | 0           | 1           | 0           | 0           | 1           | 0           |
| Sample Sizes                                                            | 30          | 28          | 19          | 19          | 19          | 19          | 19          | 19          | 19          | 19          |
| Means                                                                   | 7.23        | 8.50        | 7.55        | 8.50        | 7.91        | 8.88        | 7.89        | 8.19        | 8.50        | 8.75        |
| Medians, Q2                                                             | 7.20        | 9.00        | 7.88        | 8.56        | 7.92        | 8.75        | 8.36        | 8.58        | 8.67        | 8.63        |
| First Quartiles, Q1                                                     | 5.75        | 7.00        | 6.88        | 7.92        | 7.21        | 8.25        | 7.13        | 7.63        | 7.75        | 7.87        |
| Third Quartiles, Q3                                                     | 8.58        | 10.00       | 8.71        | 9.31        | 8.75        | 9.50        | 9.19        | 8.82        | 9.44        | 9.33        |
| Interquartile Ranges, Q3-Q1                                             | 2.83        | 3.00        | 1.83        | 1.40        | 1.54        | 1.25        | 2.06        | 1.20        | 1.69        | 1.17        |
| Mean Interquartile Range, J                                             | 2.917       | 1.615       | 1.396       | 1.629       | 1.427       | 1.933       | 2.126       | 2.208       | 2.429       | 2.183       |
| Mean Differences (H-L) in Achr-score units                              | 1.267       | .947        | .963        | .308        | .250        | .505        | .523        | .868        | .897        | 1.038       |
| Median Differences (H-L) in Achr-score units                            | 1.800       | .688        | .833        | .000        | .083        | .275        | .571        | .917        | .900        | .571        |
| Mean Differences in J units                                             | .434        | .587        | .690        | .189        | .175        | .261        | .247        | .393        | .369        | .476        |
| Median Differences in J units                                           | .617        | .426        | .597        | .000        | .058        | .142        | .270        | .415        | .371        | .262        |

## SUBJECT: ERIC (Contd)

## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED RETINOS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED, S(0) TO R(15), CONTINGENT ON LOW TONE (250 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR RESPECTIVELY (CULLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHROMATICS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIVERGENCES.

| Session Number (512 trials each)                     | 11        | 12        | 13        | 14        | 15        | 16        | 17        | 18        | 19        | 20          |
|------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-------------|
| Neutral Range, spec. as parameter, no f/back         | —         | —         | —         | —         | —         | —         | —         | —         | —         | 1/2 session |
| R/G Midpoint, specified as parameter                 | 7/8       | 7/8       | 7/8       | 7/8       | 7/8       | 7/8       | 7/8       | 7/8       | 7/8       | 7/8         |
| Feedback Ratio & Type, spec. as parameter            | 100% cond | 100% cond | 100% cond | 100% cond | 100% cond | 100% cond | 100% cond | 100% cond | 100% cond | 100% cond   |
| No. of ruined 'Assessment Trials', range 4-11        | 2         | 8         | 7         | 4         | 3         | 4         | 1         | 1         | 2         | 2           |
| Tone (Low in Left ear, High in Right ear)            | LOW       | LOW       | LOW       | LOW       | LOW       | LOW       | LOW       | LOW       | LOW       | LOW         |
| Key-cross responses, Left for R, Right for G         | R         | R         | R         | R         | R         | R         | R         | R         | R         | R           |
| (De-saturated Blue-Green)                            | 4         | 5         | 6         | 7         | 8         | 9         | 10        | 11        | 12        | 13          |
| Distributions in terms of colour-mixer               | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| Digitized settings of colour-mixer                   | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| Raw scores                                           | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| (De-saturated Red)                                   | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| Distributions in terms of colour-mixer               | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| (Max.achr. score - 8)                                | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| 'achromatics' scores                                 | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0           |
| Sample Sizes                                         | 16        | 21        | 25        | 21        | 23        | 20        | 20        | 21        | 22        | 21          |
| Means                                                | 7.50      | 8.79      | 6.90      | 8.02      | 7.02      | 8.55      | 7.41      | 9.05      | 7.20      | 8.98        |
| Medians, Q <sub>1</sub>                              | 7.60      | 8.79      | 6.92      | 8.07      | 7.08      | 8.50      | 7.50      | 9.13      | 7.40      | 9.03        |
| First Quartiles, Q <sub>2</sub>                      | 6.67      | 8.04      | 5.31      | 6.93      | 5.85      | 7.55      | 6.55      | 8.33      | 6.00      | 8.05        |
| Third Quartiles, Q <sub>3</sub>                      | 8.40      | 9.63      | 7.96      | 9.21      | 8.15      | 9.55      | 8.38      | 9.75      | 8.40      | 9.96        |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> | 1.73      | 1.59      | 2.15      | 2.26      | 2.30      | 2.00      | 1.83      | 1.42      | 2.40      | 1.91        |
| Mean Interquartile Range, J                          | 1.66      | 2.20      | 2.15      | 1.62      | 2.15      | 2.05      | 1.62      | 1.75      | 2.05      | 1.89        |
| Mean Differences (H-L) in Ach-score units            | 1.28      | 1.16      | 1.53      | 1.63      | 2.79      | 2.72      | 2.74      | 1.37      | 1.64      | 1.92        |
| Median Differences (H-L) in Ach-score units          | 1.12      | 1.15      | 1.47      | 1.62      | 1.83      | 2.08      | 1.63      | 1.06      | 1.47      | 1.58        |
| Mean Differences in J units                          | .774      | .507      | .711      | 1.011     | 1.298     | .134      | .780      | .863      | .838      | .838        |
| Median Differences in J units                        | .714      | .524      | .659      | 1.003     | .781      | .041      | .606      | .776      | .692      | .692        |

## CONDITIONING OF TONE-CONTINGENT HUE-RESPONSES: EXPERIMENTAL DATA

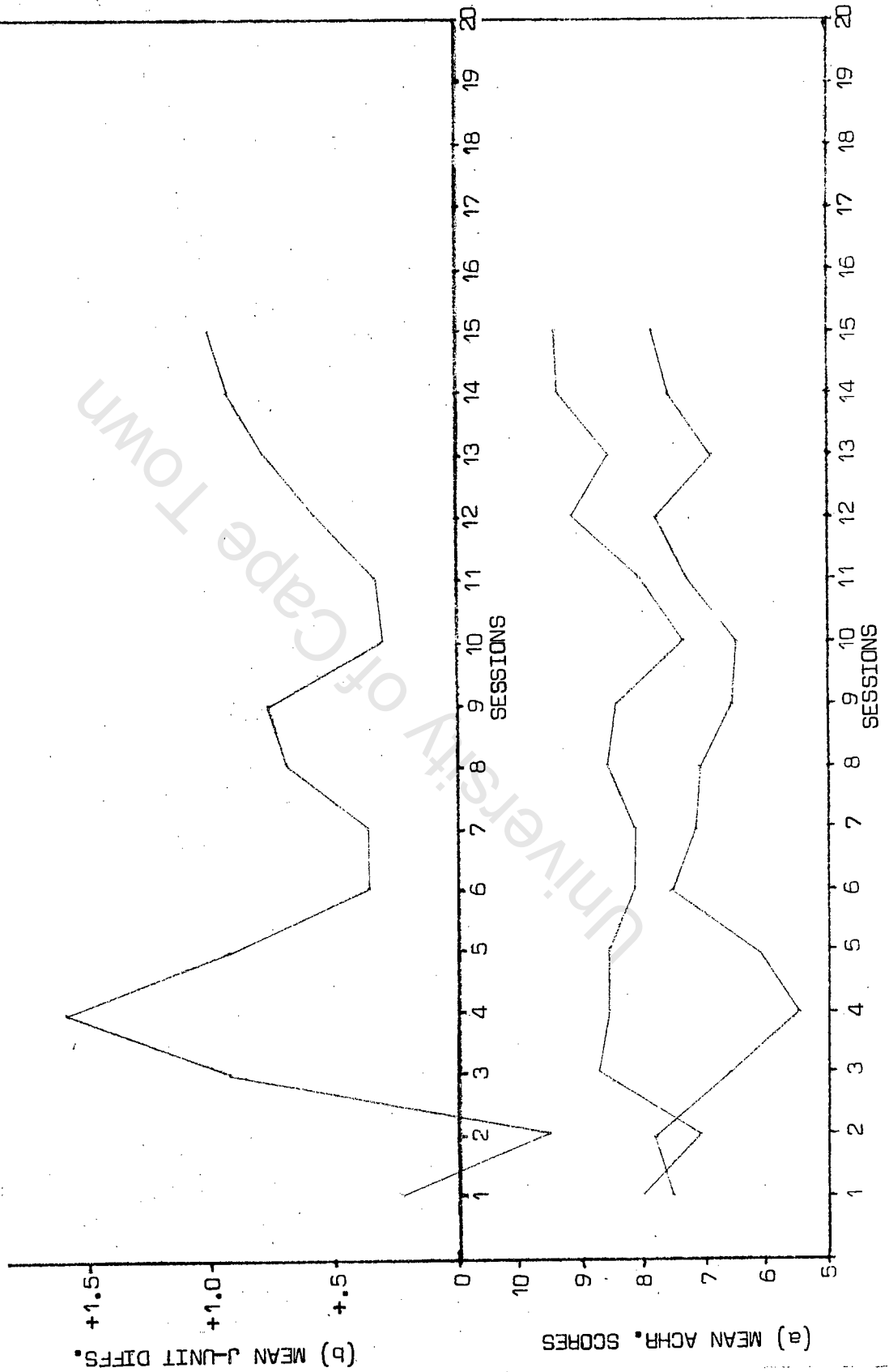
SUBJECT: MIKE

WITHIN-SESSION 'ASSESSMENT TRIALS': DISTRIBUTIONS OF (a) KEY-PRESSING RESPONSES (RED OR GREEN) TO DIGITIZED SETTINGS 4 THROUGH 11 OF UNSATURATED RANGE, BLUE-GREEN TO RED,  $g(g)$  to  $r(r)$  (15), CONTINGENT ON LOW TONE (2.5C HZ) IN LEFT EAR AND HIGH TONE (330 HZ) IN RIGHT EAR RESPECTIVELY (CULLED FROM COMPUTER PRINTOUT), AND (b) DERIVED 'ACHROMATONNESS' SCORES FOR BOUNDARY VALUES OF DIGITIZED SETTINGS, 4.5 TO 10.5 AND CORRESPONDING STATISTICS SHOWING TONE-CONTINGENT DIVERGENCES.

| Session Number (512 trials each)              | 1        | 2        | 3        | 4        | 5         | 6         | 7         | 8         | 9         | 10        |
|-----------------------------------------------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Neutral Range, spec. as parameter, no f/back  | 7.8      | 7.8      | 7.8      | 6.7, 8.9 | 5.0, 10.0 | 3.0, 10.0 | 3.0, 10.0 | 3.0, 10.0 | 4.0, 10.0 | 4.0, 10.0 |
| R/G midpoint, specified as parameter          | 7.8      | 7.8      | 7.8      | 7.8      | 7.8       | 6.7       | 6.7       | 6.7       | 7.8       | 7.8       |
| Feedback Ratio & Type, spec. as parameter     | 100% +ve | 100% +ve | 100% +ve | 100% -ve | 100% -ve  | 100% -ve  | 100% -ve  | 100% -ve  | 100% -ve  | 100% -ve  |
| No. of ruined 'Assessment Trials', range 4-11 | 8        | 6        | 10       | 5        | 5         | 0         | 1         | 0         | 3         | 0         |
| Tone (Low in Left ear, High in Right ear)     | LOW      | HIGH     | LOW      | LOW      | HIGH      | LOW       | HIGH      | LOW       | HIGH      | LOW       |
| Key-press responses, Left for R, Right for G  | A        | G        | A        | A        | G         | A         | A         | G         | A         | G         |
| (De-saturated Blue-Green)                     | A        | G        | A        | A        | G         | A         | A         | G         | A         | G         |
| Distributions                                 | 4        | 5        | 3        | 0        | 1         | 7         | 0         | 8         | 1         | 0         |
| in                                            | 5        | 4        | 0        | 6        | 3         | 5         | 0         | 7         | 4         | 0         |
| terms                                         | 6        | 2        | 0        | 1        | 7         | 1         | 5         | 4         | 0         | 7         |
| of                                            | 7        | 6        | 2        | 1        | 6         | 0         | 8         | 1         | 7         | 4         |
| of colour-mixer                               | 8        | 3        | 3        | 0        | 8         | 4         | 3         | 5         | 2         | 0         |
| raw                                           | 9        | 7        | 1        | 0        | 8         | 4         | 3         | 5         | 1         | 4         |
| scores                                        | 10       | 6        | 2        | 2        | 5         | 0         | 5         | 2         | 7         | 1         |
| (De-saturated Red)                            | 11       | 7        | 1        | 1        | 7         | 8         | 0         | 8         | 0         | 5         |
| Distributions                                 | 4.5      | 7        | 0        | 4        | 0         | 3         | 0         | 7         | 0         | 5         |
| Boundaries, in                                | 5.5      | 6        | 0        | 4        | 1         | 6         | 0         | 7         | 0         | 5         |
| digitized settings                            | 6.5      | 4        | 1        | 1        | 2         | 8         | 2         | 5         | 0         | 6         |
| of colour-mixer                               | 7.5      | 5        | 1        | 4        | 4         | 6         | 6         | 4         | 3         | 4         |
| (Max.achr. score = 8)                         | 8.5      | 4        | 0        | 7        | 7         | 3         | 6         | 3         | 7         | 3         |
| 'achromativeness'                             | 9.5      | 3        | 2        | 3        | 5         | 2         | 6         | 1         | 7         | 2         |
| scores                                        | 10.5     | 3        | 2        | 3        | 0         | 2         | 1         | 3         | 1         | 5         |
| Sample Sizes                                  | 32       | 7        | 23       | 21       | 29        | 23        | 28        | 22        | 25        | 24        |
| Means                                         | 6.94     | 9.21     | 7.15     | 8.41     | 6.85      | 8.59      | 6.36      | 9.14      | 6.54      | 9.13      |
| Medians, Q2                                   | 6.75     | 9.75     | 7.63     | 8.50     | 6.69      | 8.58      | 6.00      | 9.11      | 6.42      | 9.38      |
| First Quartiles, Q1                           | 5.17     | 7.75     | 5.44     | 7.56     | 5.71      | 7.63      | 5.00      | 8.36      | 5.25      | 8.40      |
| Third Quartiles, Q3                           | 8.50     | 10.42    | 8.61     | 9.35     | 7.79      | 9.54      | 7.50      | 9.93      | 7.69      | 10.14     |
| Interquartile Ranges, Q3-Q1                   | 3.33     | 2.67     | 3.17     | 1.79     | 2.08      | 1.92      | 2.50      | 1.57      | 2.44      | 1.74      |
| Mean Interquartile Range, J                   | 3.000    | 2.479    | 2.000    | 2.036    | 2.090     |           |           |           |           |           |
| Mean Differences (H-L) in Achr-score units    | 2.277    | 1.253    | 1.742    | 2.780    | 2.585     |           |           |           |           |           |
| Median Differences (H-L) in Achr-score units  | 3.000    | .875     | 1.896    | 3.143    | 2.958     |           |           |           |           |           |
| Mean Differences in J units                   | .752     | .506     | .870     | 1.364    | 1.238     |           |           |           |           |           |
| Median Differences in J units                 | 1.000    | .353     | .948     | 1.544    | 1.415     |           |           |           |           |           |

CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

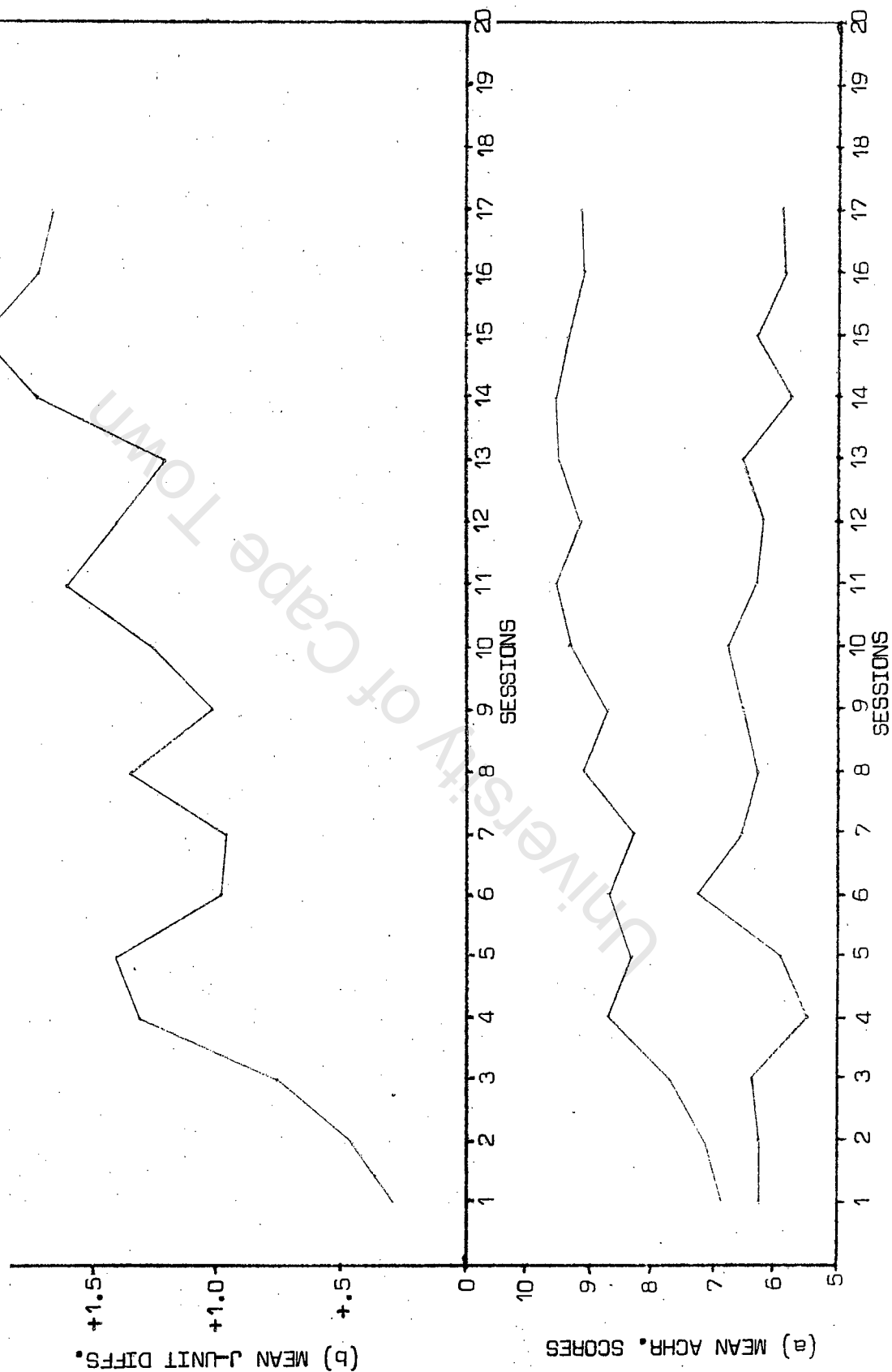
SUBJECT: STAN





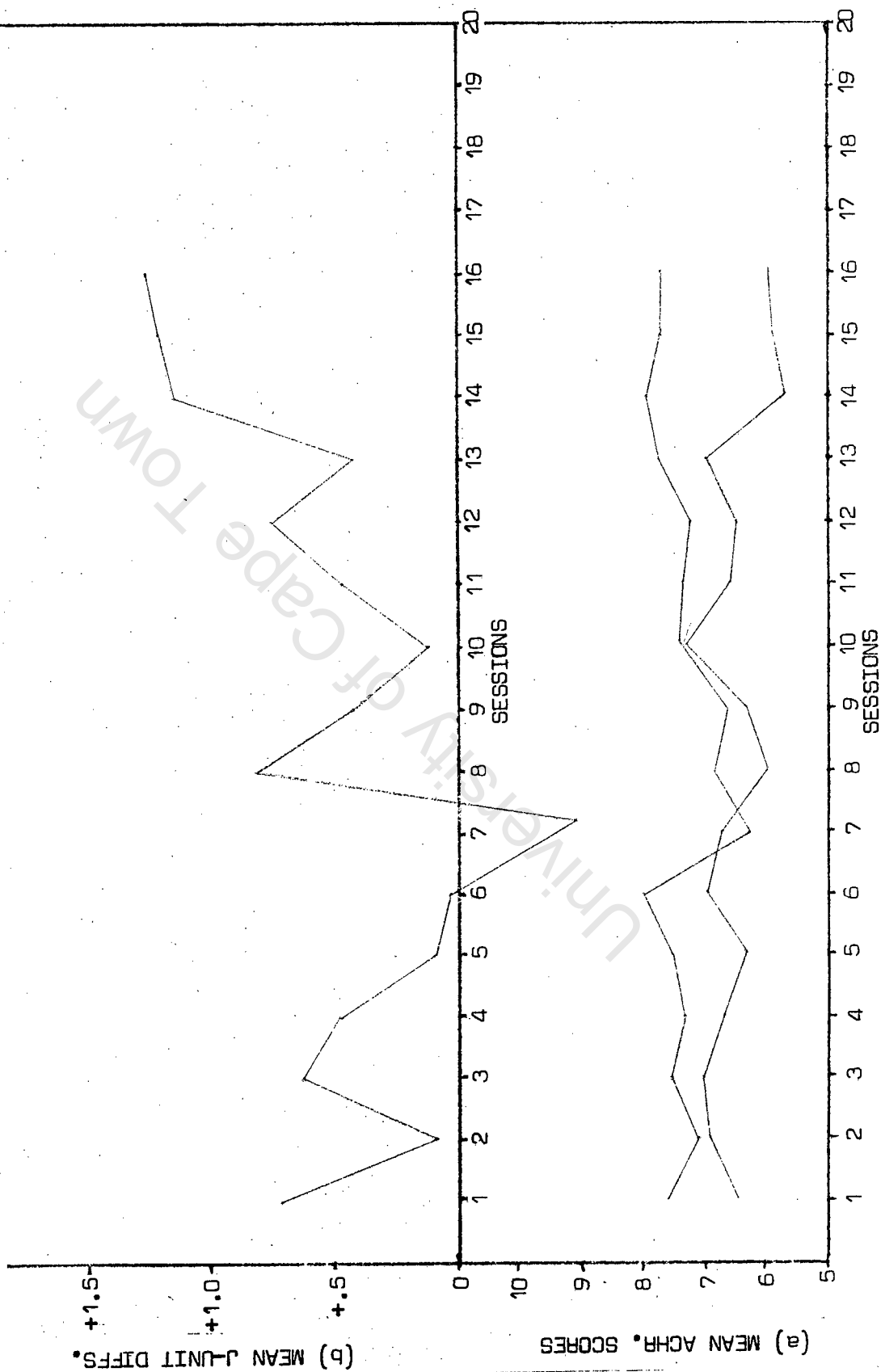
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

SUBJECT: STEVE



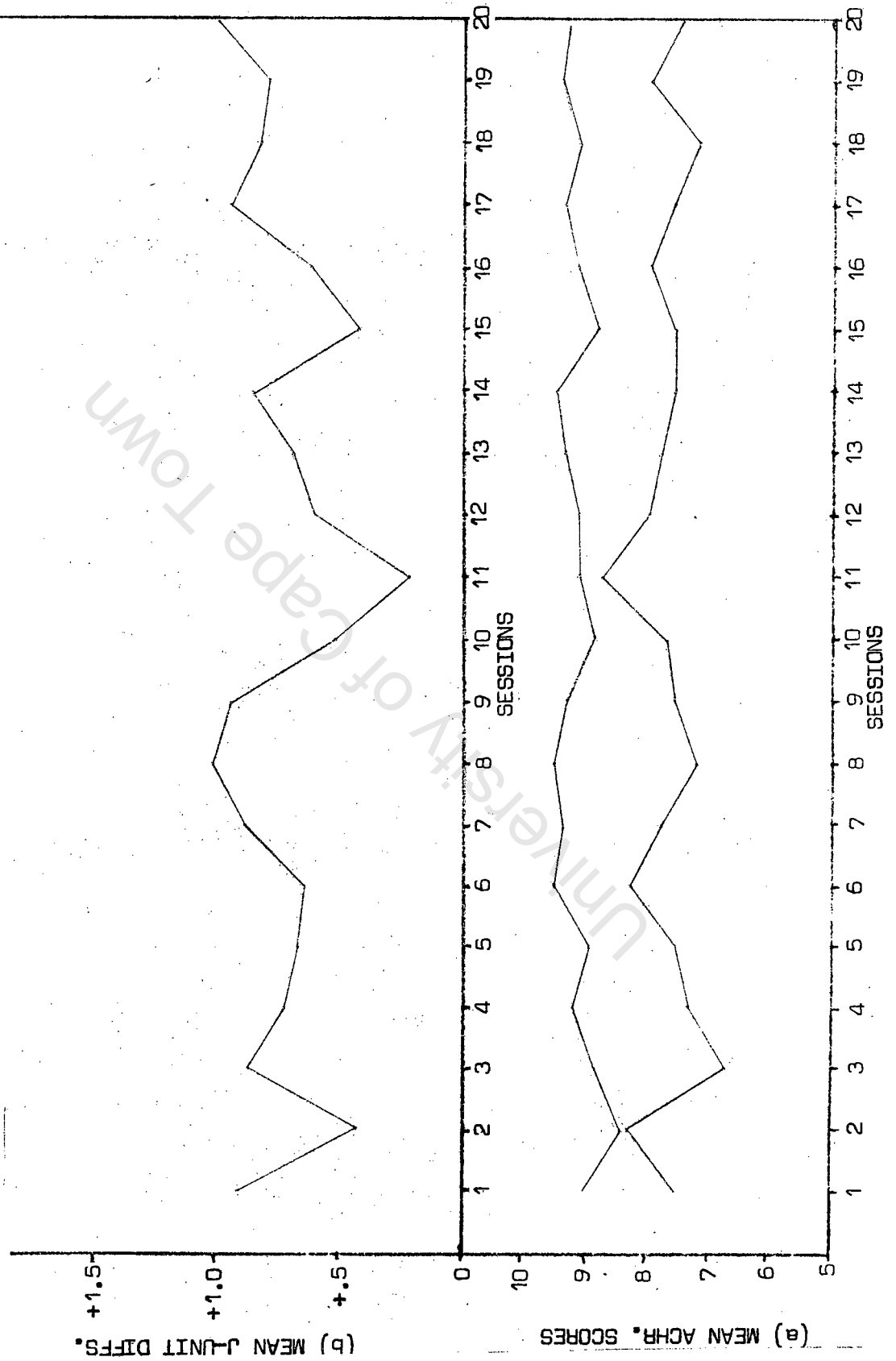
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SUBJECT: NEVIL



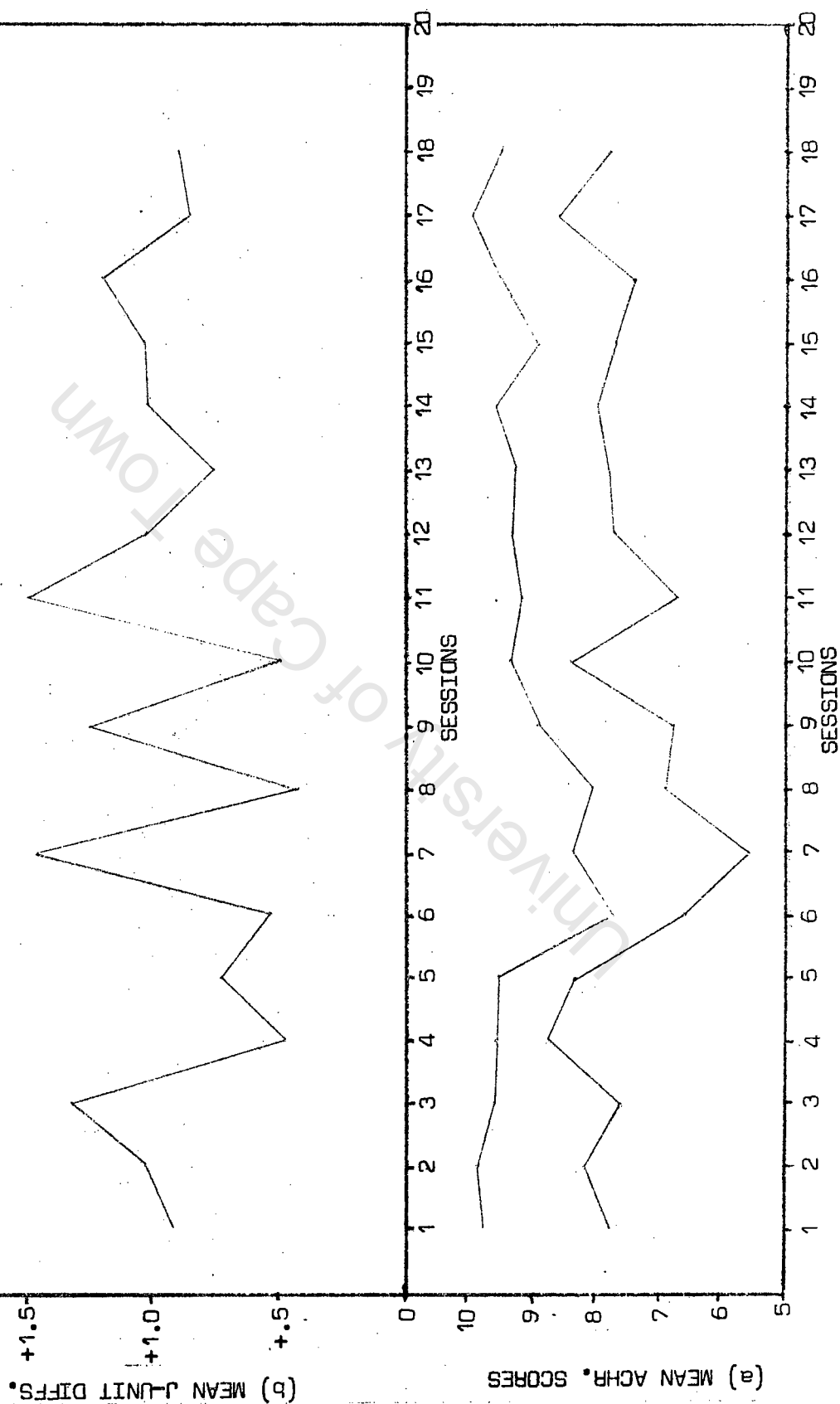
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

SUBJECT: SILKE



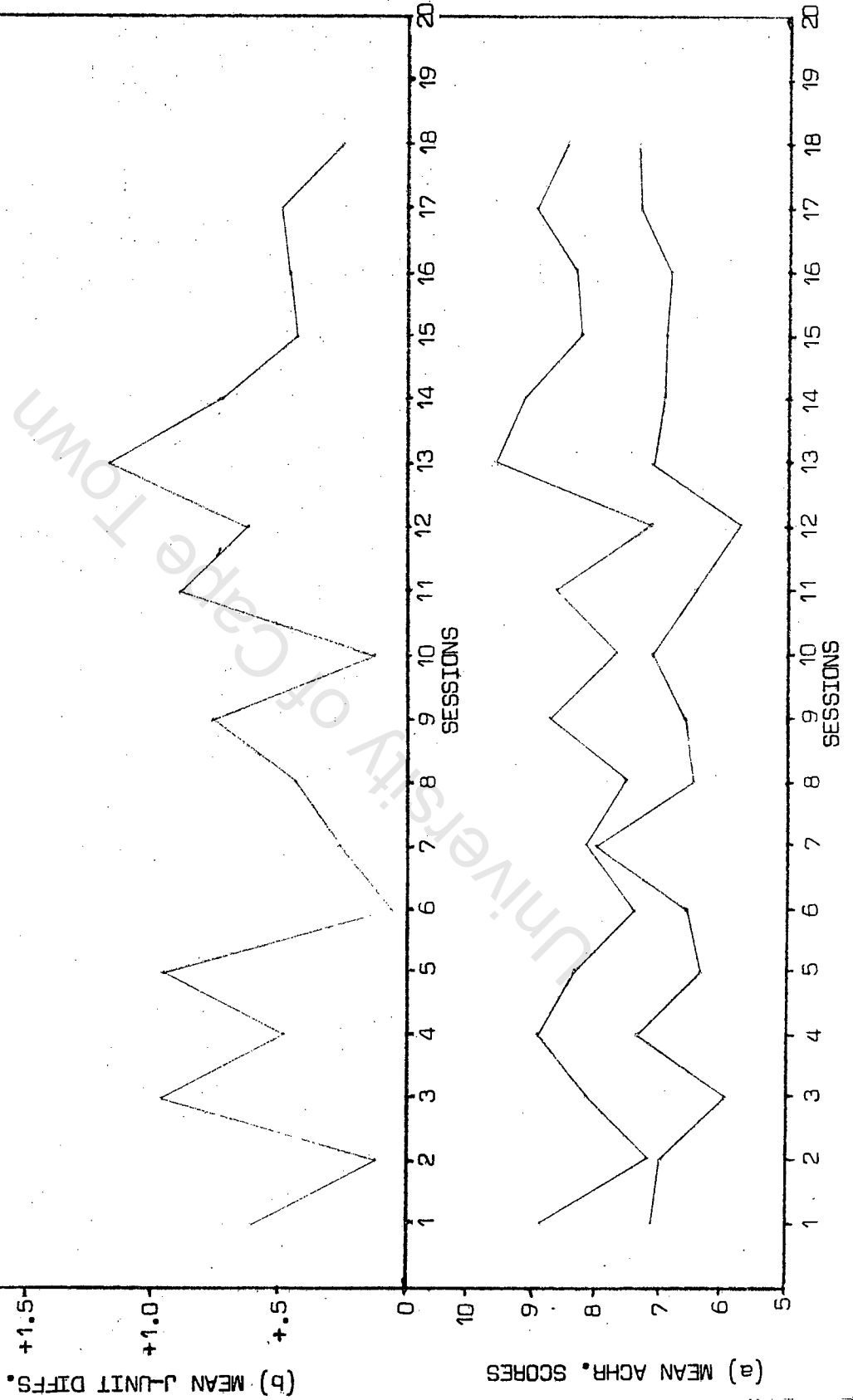
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

SUBJECT: JOAN



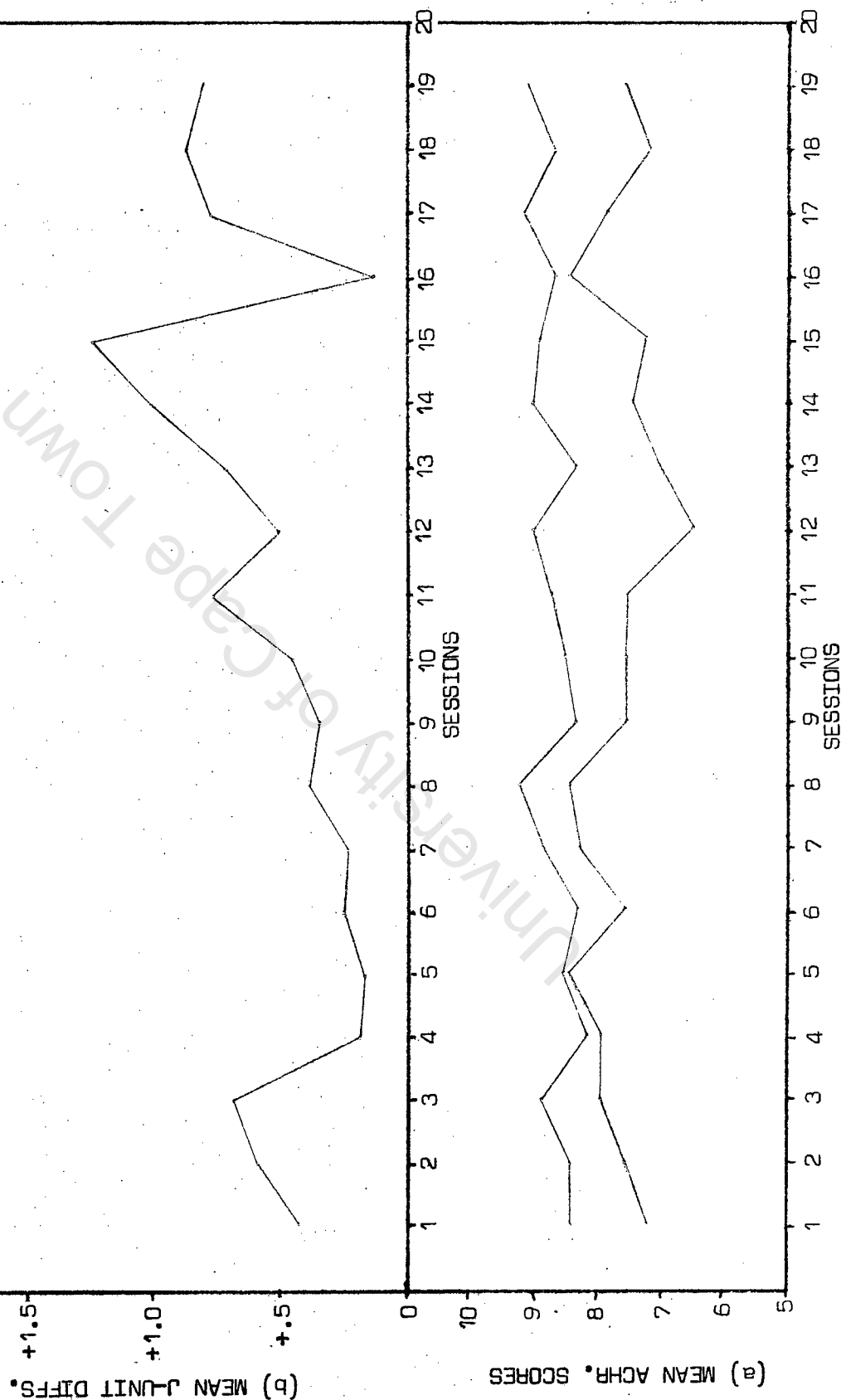
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

SUBJECT: EMILY



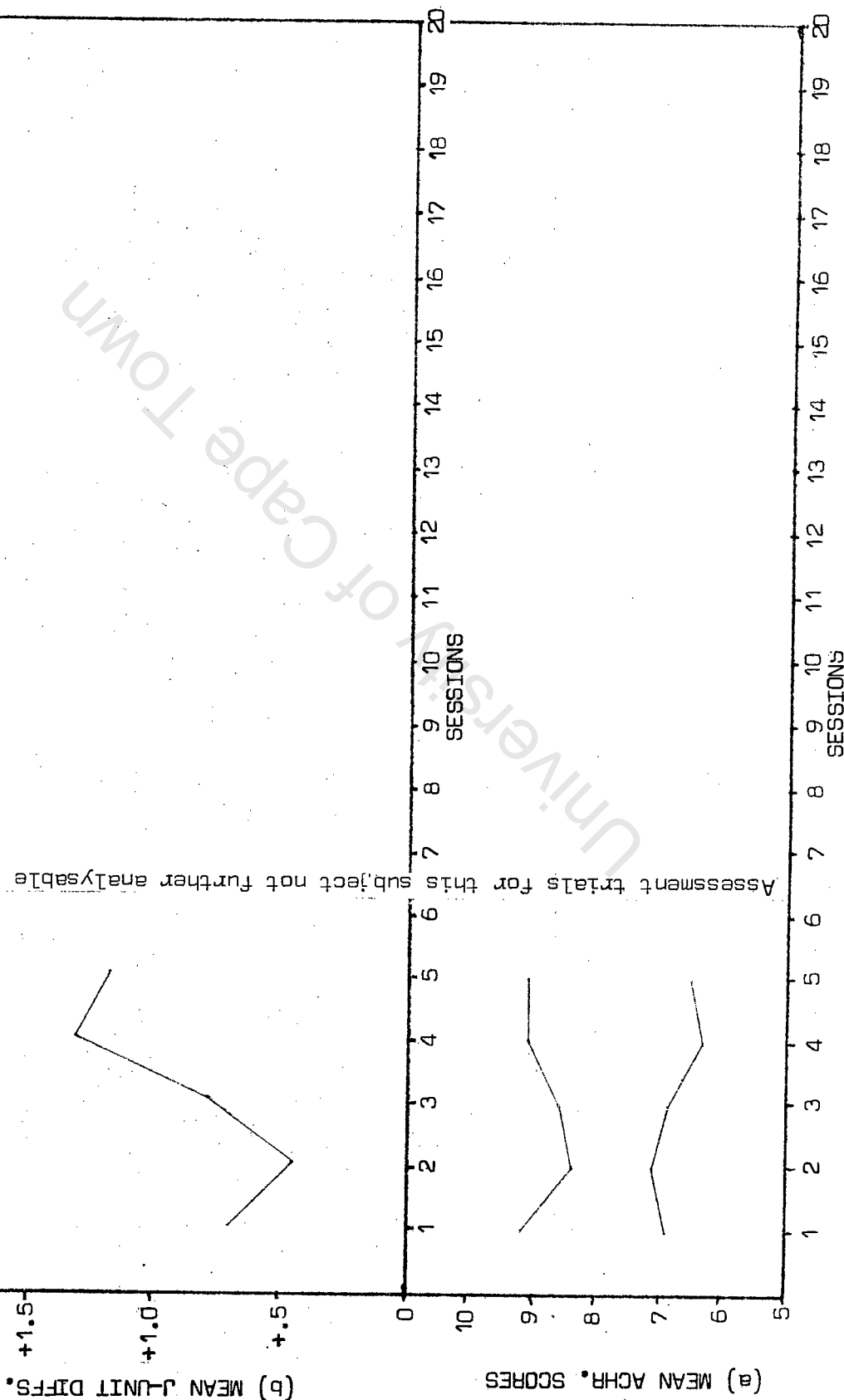
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

SUBJECT: ERIC



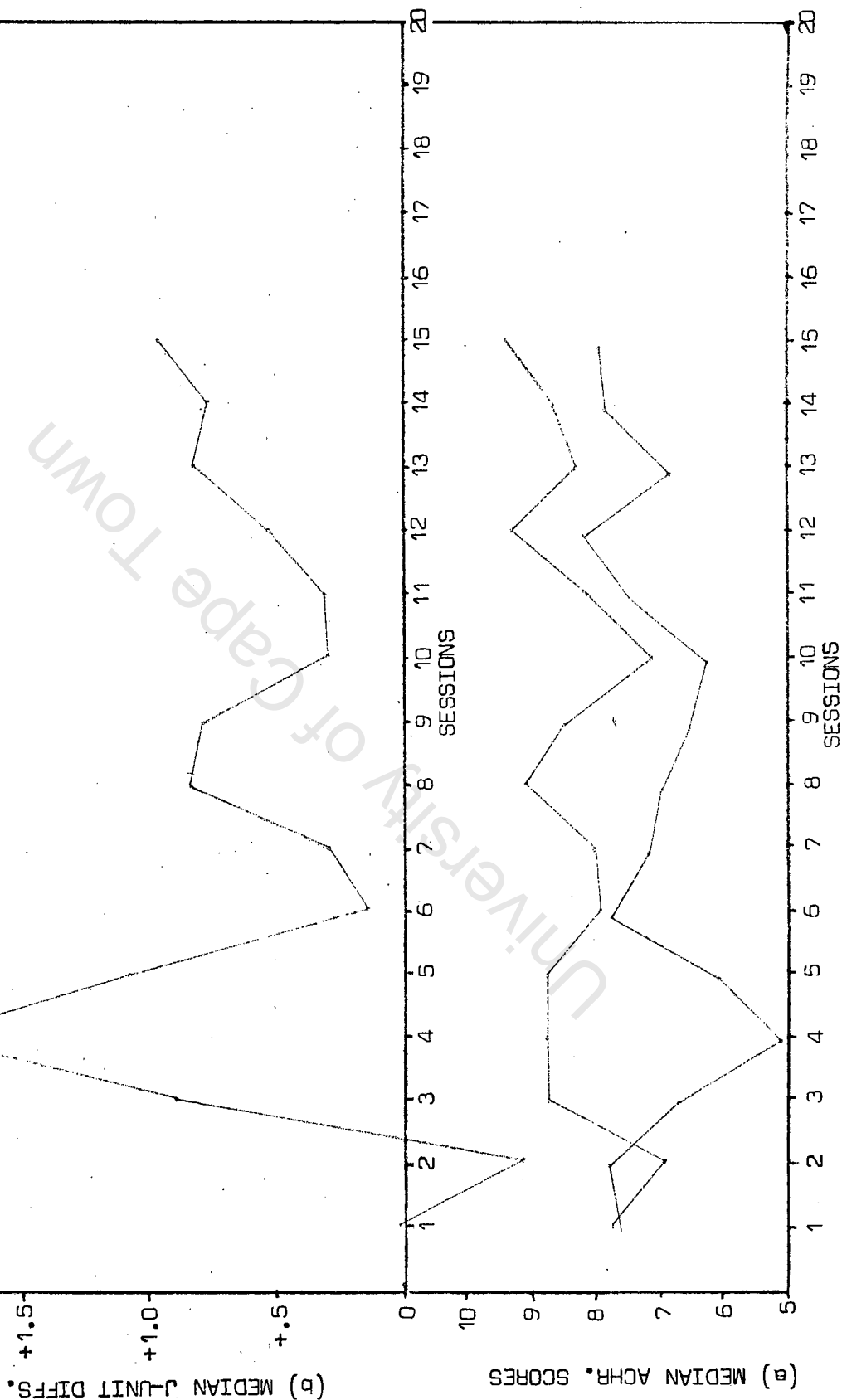
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEAN J-UNIT DIFFERENCES

SUBJECT: MIKE



CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

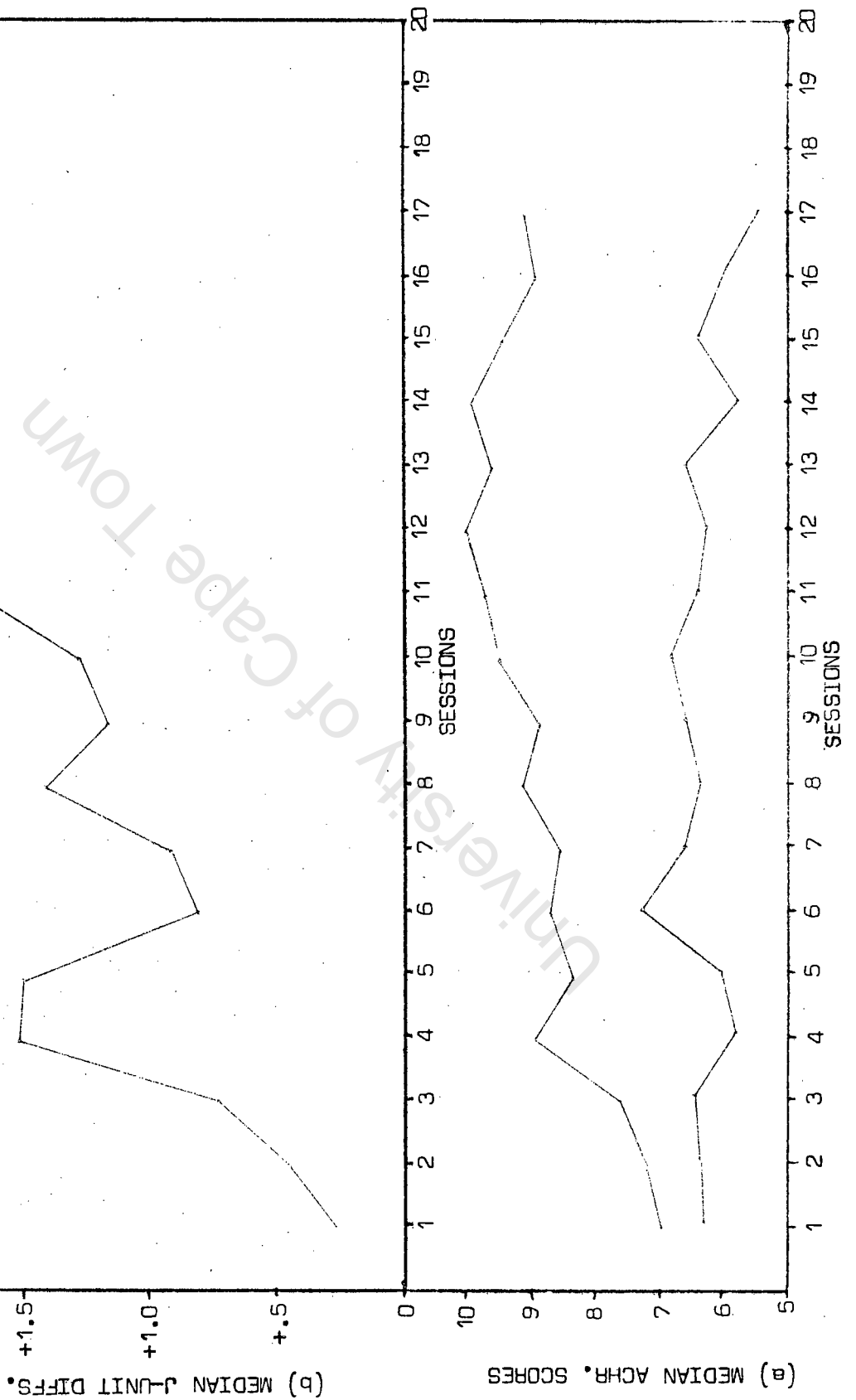
SUBJECT: STAN





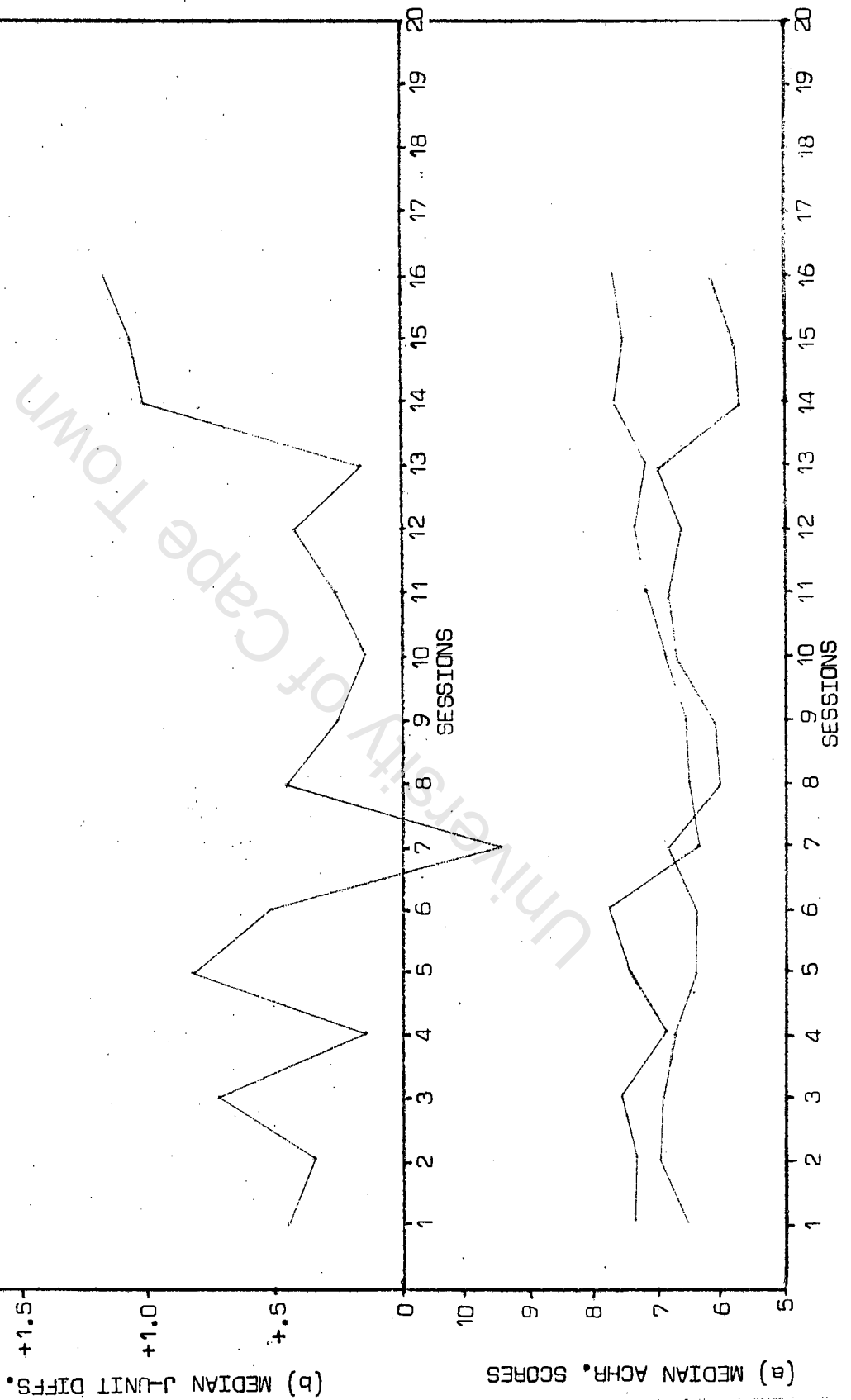
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

SUBJECT: STEVE



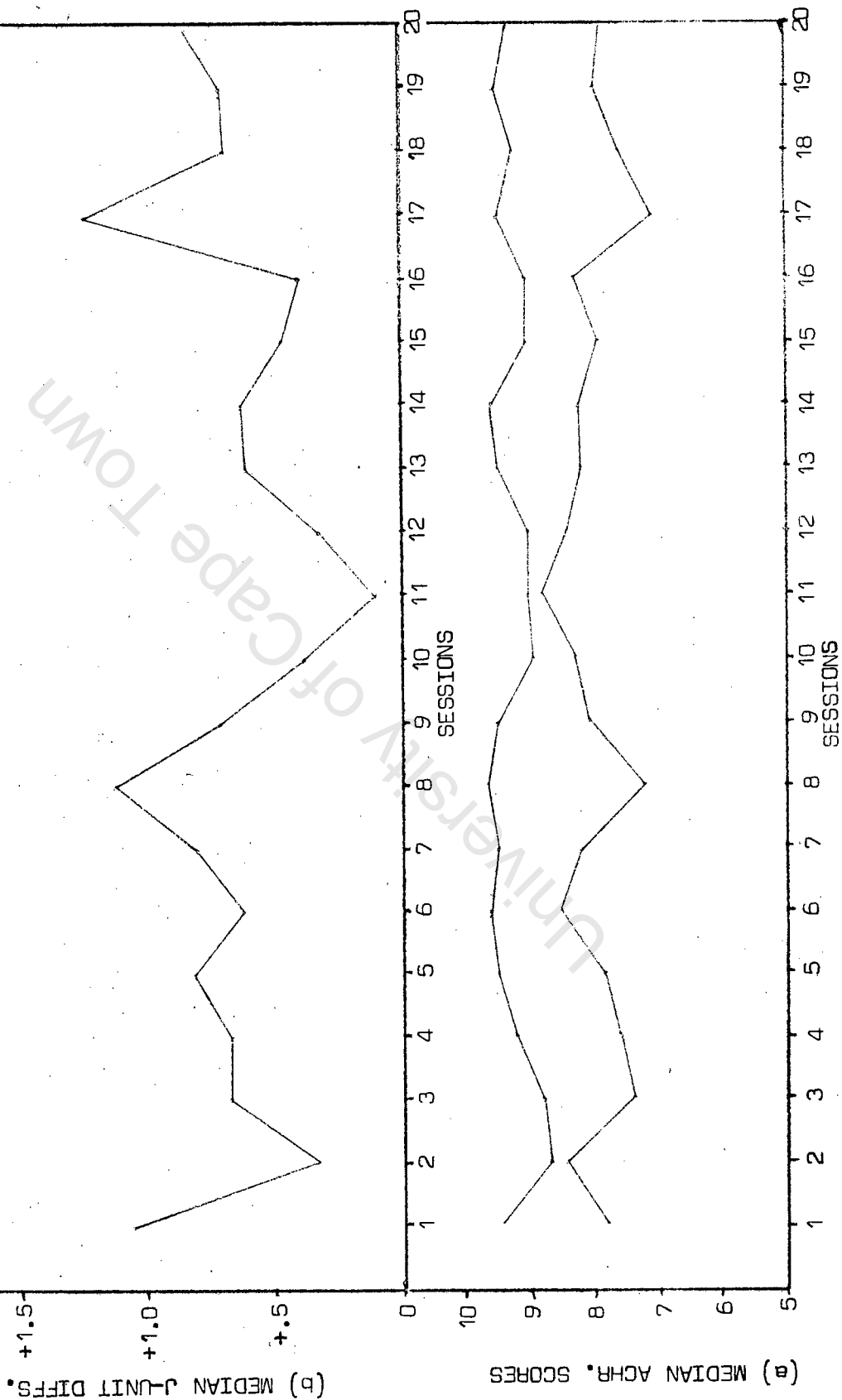
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

SUBJECT: NEVIL



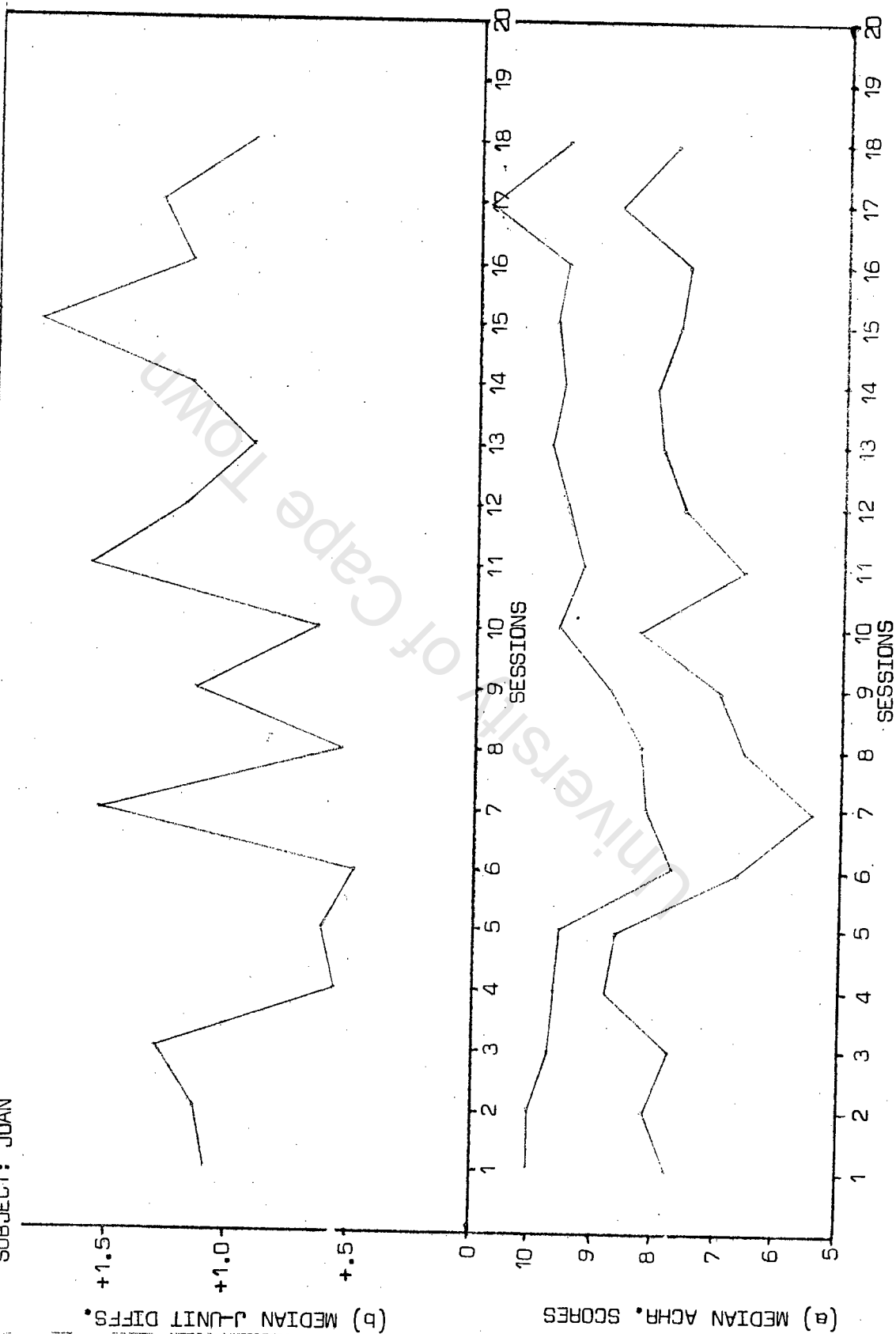
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

SUBJECT: SILKE



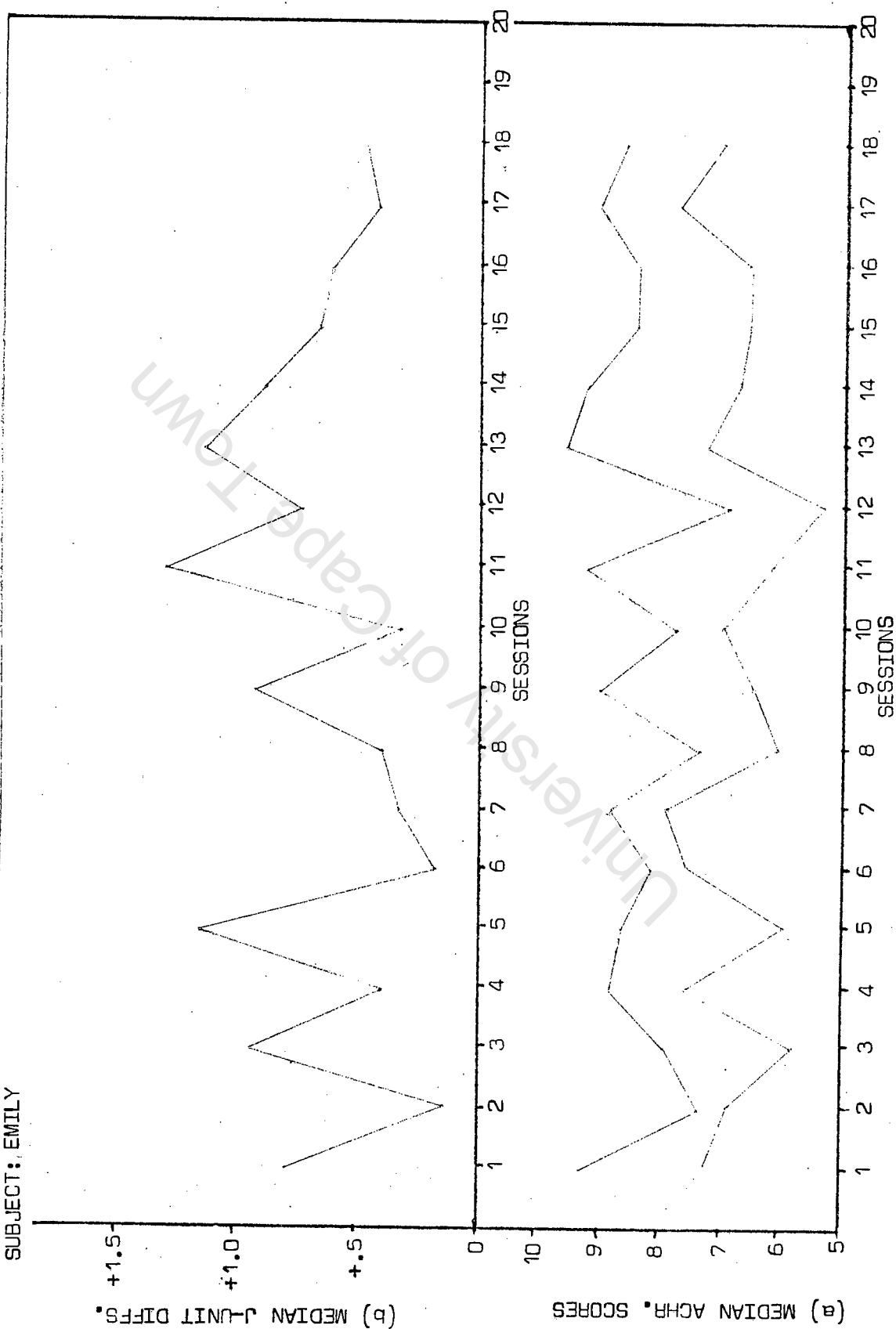
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

SUBJECT: JOAN



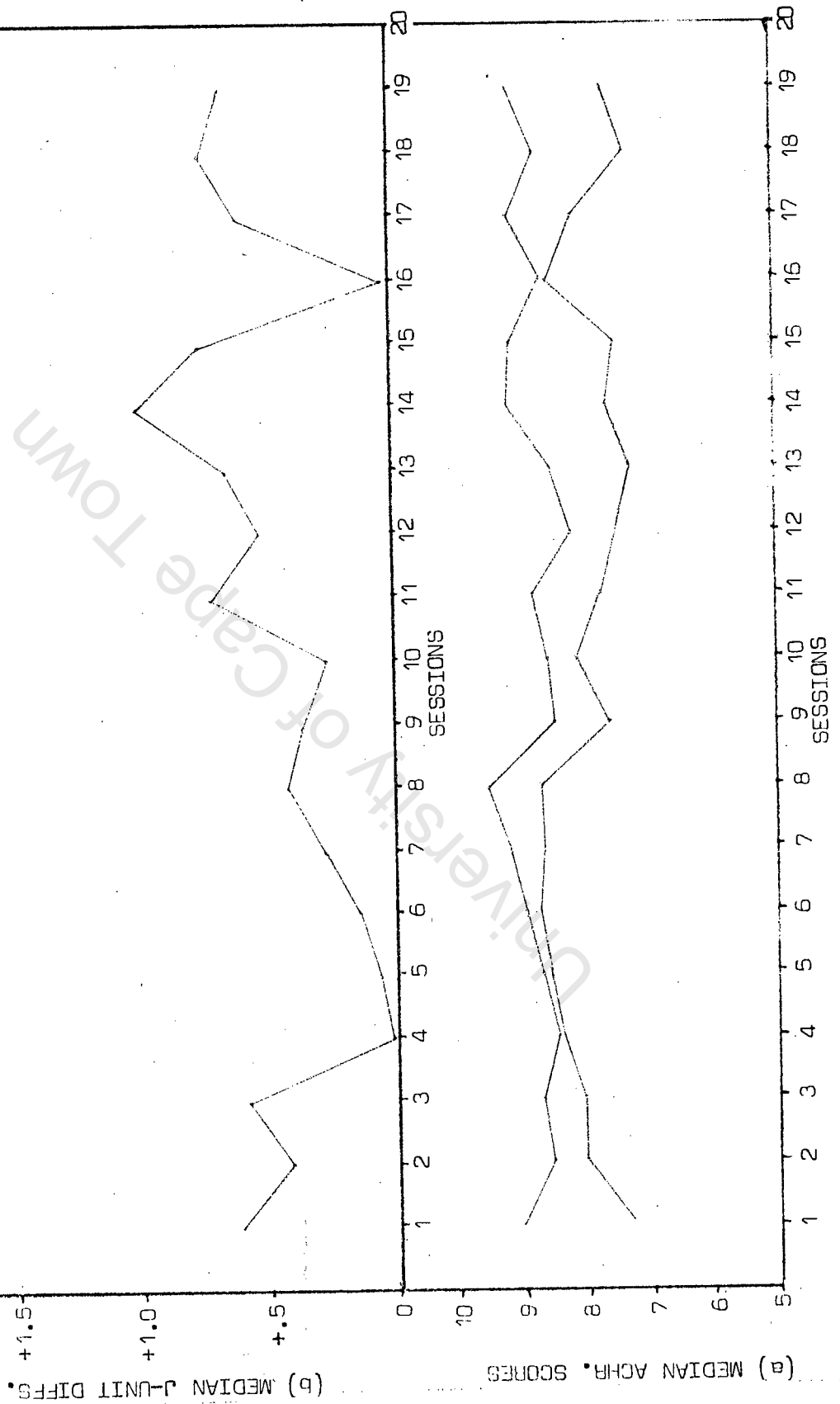
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

SUBJECT: EMILY



CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (250 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

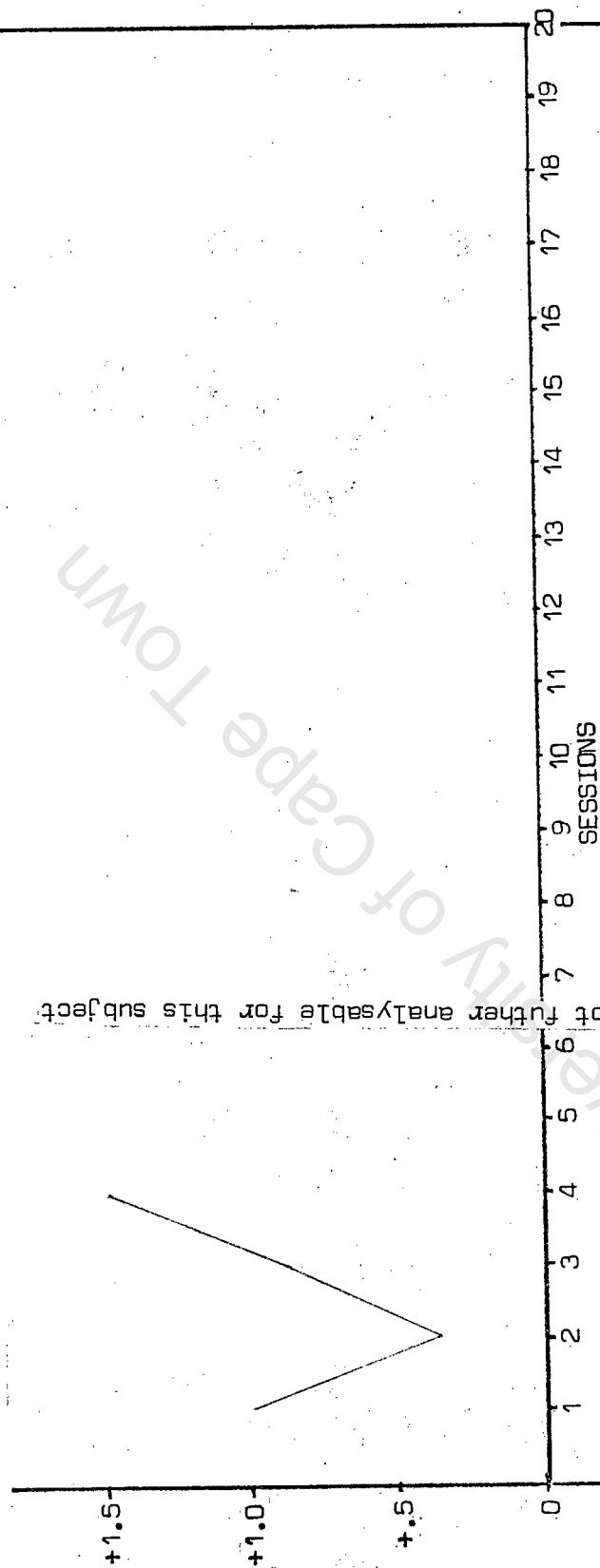
SUBJECT: ERIC



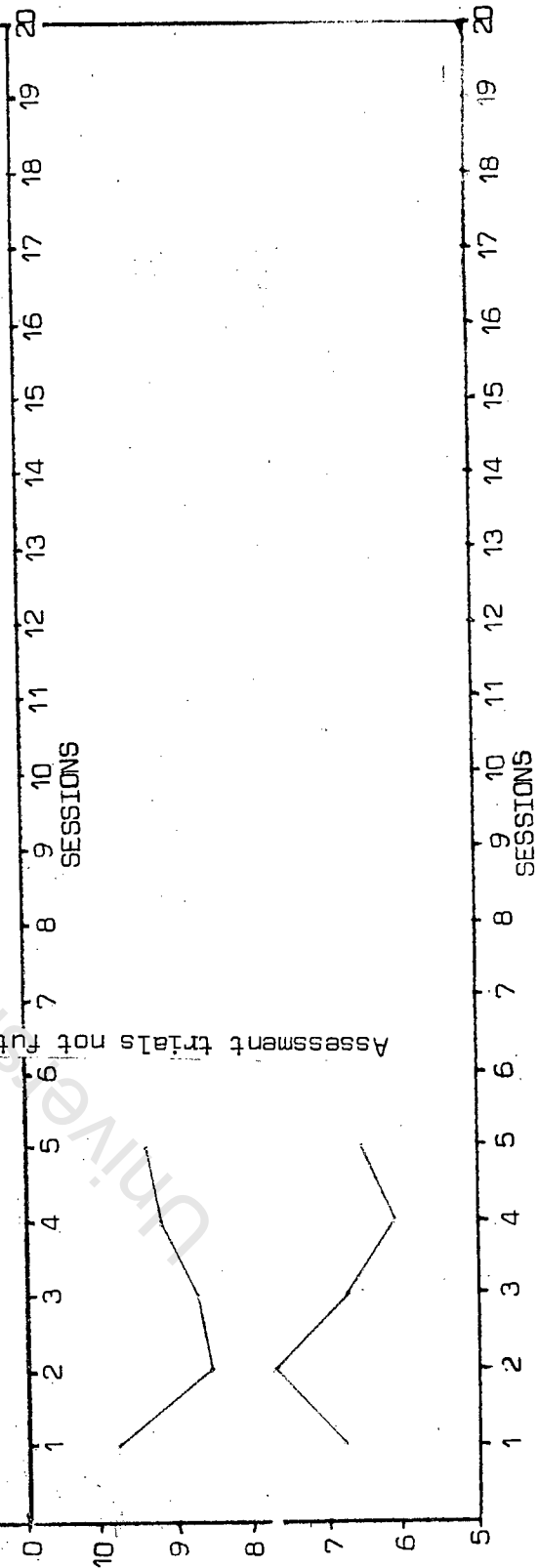
CONDITIONING OF TONE-CONTINGENT HUE RESPONSES: GRAPHS OF (a) MEDIAN ACHROMATICNESS SCORES CONTINGENT ON LOW TONE (260 Hz) IN LEFT EAR AND HIGH TONE (390 Hz) IN RIGHT EAR, & (b) MEDIAN J-UNIT DIFFERENCES

SUBJECT: MIKE

(b) MEDIAN J-UNIT DIFFS.



(a) MEDIAN ACHR. SCORES



# Appendix 10

## CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: FORTRAN PROGRAMME LISTINGS

```

0001  FTV,B
0002      PROGRAM PHDK
0003      DIMENSION  ICOL1(200),ICOL2(200),IDIG1(200),IDIG2(200)
0004      DIMENSION  ID(10),NAME(10),ISX(3,8),VSAME(3,8)
0005      DIMENSION  ATSC(3,8),ATSK(3,8),DEVSC(3,8),DEVSK(3,8)
0006      DIMENSION  TDAWS(3,8),SDAWS(3,8)
0007      COMMON  ITIME,INPUT,IOUTPUT,ISWOT,ITIMP,ITIMI,ITIME,
0008      1 IDIFF,IROVG,LATEN,IC1,IC2,IDI,ID2,IDAWD
0009  C
0010  500  WRITE (2,10)
0011  10   FORMAT (4/,20X,"ABRAMOVITZ - PHD.K")
0012      WRITE (2,11)
0013  11   FORMAT (/,"DATE : -")
0014      READ (1,12) (ID(I),I=1,10)
0015  12   FORMAT (10A2)
0016      WRITE (2,13)
0017  13   FORMAT (/,"SUBJECT : -")
0018      READ (1,12) (NAME(I),I=1,10)
0019      WRITE (2,14)
0020  14   FORMAT (/,"BLOCK VFEED SESSV")
0021      READ (1,*) IBLCN,VFEED,ISESV
0022      WRITE (2,15)
0023  15   FORMAT (/,"TIMEP TIMEI TIMEF TIMES")
0024      READ (1,*) ITIMP,ITIMI,ITIME,ITIMS
0025      WRITE (2,16)
0026  16   FORMAT (/,"STARTING TRIAL NO : -")
0027      READ (1,*) NTRL
0028  C
0029      DO 100 I = 1,IBLCN
0030  100  READ (5,*) ICOL1(I),IDIG1(I),ICOL2(I),IDIG2(I)
0031  C
0032      DO 102 I = 1,3
0033      DO 102 J = 1,8
0034          VSAME(I,J) = 0
0035          ISX(I,J) = 0
0036          ATSC(I,J) = 0.
0037          ATSK(I,J) = 0.
0038          TDAWS(I,J) = 0.
0039          SDAWS(I,J) = 0.
0040          DEVSC(I,J) = 0.
0041          DEVSK(I,J) = 0.
0042  102  CONTINUE
0043      VDIFF = 0
0044      IDX = 0
0045      ATDC = 0.
0046      ATPX = 0.
0047      DEVDC = 0.
0048      DEVDX = 0.
0049      TDAWD = 0.
0050      SDAWD = 0.
0051      DA = 0.
0052      DS = 0.
0053      V = 0
0054      IX = 0
0055      S = 0.
0056      A = 0.
0057      INIT = NTRL
0058      NTRL = NTRL - 1
0059      WRITE (2,20)

```



```

0060      PAUSE
0061 C
0062      CALL TIMER
0063      IOPUT = 2000
0064      ITIME = 0
0065 105   CONTINUE
0066      IF (ITIME - ITIME) 105,107,107
0067 107   IOPUT = 0
0068 C
0069 501   DO 200 I = 1,IRLCN
0070      IC1 = ICOL1(I)
0071      IC2 = ICOL2(I)
0072      ID1 = IDIG1(I)
0073      ID2 = IDIG2(I)
0074 C
0075      CALL OUTK
0076      ID1 = ID1 + 1
0077      ATE = LATEV
0078      SATE = ATE**2
0079      DAW = IDAWV
0080      SDAW = DAW**2
0081      GO TO (220,210),IDIFF
0082 210   NSAME(IC1,ID1) = NSAME(IC1,ID1) + 1
0083      IF (IRONG) 214,214,212
0084 214   ATSC (IC1,ID1) = ATSC (IC1,ID1) + ATE
0085      DEVSC(IC1,ID1) = DEVSC(IC1,ID1) + SATE
0086      GO TO 230
0087 212   ATSX (IC1,ID1) = ATSX (IC1,ID1) + ATE
0088      DEVSX(IC1,ID1) = DEVSX(IC1,ID1) + SATE
0089      TDAWS(IC1,ID1) = TDAWS(IC1,ID1) + DAW
0090      SDAWS(IC1,ID1) = SDAWS(IC1,ID1) + SDAW
0091      ISX(IC1,ID1) = ISX(IC1,ID1) + 1
0092      GO TO 230
0093 220   NDIFF = NDIFF + 1
0094      IF (IRONG) 224,224,222
0095 224   ATDC = ATDC + ATE
0096      DEVDC = DEVDC + SATE
0097      GO TO 230
0098 222   ATDX = ATDX + ATE
0099      DEVDX = DEVDX + SATE
0100      TDAWD = TDAWD + DAW
0101      SDAWD = SDAWD + SDAW
0102      IDX = IDX + 1
0103 230   V = V + 1
0104      IF (IRONG) 232,232,233
0105 233   IX = IX + 1
0106      DA = DA + DAW
0107      DS = DS + SDAW
0108 232   A = A + ATE
0109      S = S + SATE
0110      NTRL = NTRL + 1
0111      IF (V - VFEEED) 200,240,240
0112 240   AV = V
0113      AIX = IX
0114      DS = SORT ((DS - (DA**2/AIX))/(AIX-1.))
0115      DA = DA/AIX
0116      AIX = AIX/AV * 100.
0117      AIX = 100. - AIX
0118      S = SORT ((S - (A**2/AV))/(AV - 1.))
0119      A = A/AV

```

```

0120      IF (IREV(1) - J)120,130,120
0121 130  IFREV = 1
0122      GO TO 140
0123 120  IFREV = 0
0124 140  IOPS = 1
0125      IFERF = 1
0126      IF (ISTIM) 141,145,145
0127 141  IOPS = ISTIM + 3
0128      GO TO 180
0129 145  IF (STIM - ALLOW) 146,146,150
0130 146  IOPS = 2
0131      GO TO 180
0132 150  IF (STIM - AMID) 151,151,155
0133 151  IOPS = 2
0134      IFERF = 0
0135      GO TO 180
0136 155  IF (STIM - HIGH) 156,156,180
0137 156  IFERF = 0
0138 180  IF (IFERF) 160,160,165
0139 165  IF (VERNV - INEGV) 166,167,168
0140 166  IFENV = 0
0141      GO TO 170
0142 167  IFENV = 1
0143      GO TO 170
0144 168  VERNV = 1
0145      GO TO 165
0146 170  IF (VERVR - INEGR) 171,172,173
0147 171  IFEVR = 0
0148      GO TO 175
0149 172  IFEVR = 1
0150      GO TO 175
0151 173  VERNR = 1
0152      GO TO 170
0153 175  IF (VERPV - IPOSV) 176,177,178
0154 176  IFEPV = 0
0155      GO TO 181
0156 177  IFEPV = 1
0157      GO TO 181
0158 178  VERPV = 1
0159      GO TO 175
0160 181  IF (VERPR - IPOSR) 182,183,184
0161 182  IFEPR = 0
0162      GO TO 160
0163 183  IFEPR = 1
0164      GO TO 160
0165 184  VERPR = 1
0166      GO TO 181
0167 160  CALL OUTA
0168  C
0169      ISTIM = ISTIM + 3
0170      IFREV = IFREV + 1
0171      NTRL = NTRL + 1
0172      IF (IER1) 205,205,210
0173 210  ILATRC(ISTIM,IFREV) = IFARL(ISTIM,IFREV) + 1
0174      JERR = JERR + 1
0175      VER = VER + 1
0176      IER = IER + 1
0177      GO TO 205
0178 205  IF (IER3) 215,215,220
0179 220  ILATRC(ISTIM,IFREV) = ILATRC(ISTIM,IFREV) + 1

```

```
0180      I TDWD,SDWD  
0181      WRITE (2,10)  
0182      GO TO 500  
0183      FDD  
0184      ENDS
```

```
**END-OF-TAPE
```

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```
/E
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*END
```

University of Cape Town

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES  
DIARY OF TRAINING AND TESTING PROCEDURES

SUBJECT: Paula

| <u>Date</u> | <u>Exp. Day</u> | <u>Testing Sessions</u>                                                                                                                                                                                     | <u>Training</u>        |                                    |
|-------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------|
|             |                 |                                                                                                                                                                                                             | <u>No. of Sessions</u> | <u>Total Duration (Nett) hours</u> |
| March 2     | 1               | (1) Laterality bias in viewing system<br>(2) Viewing filters' characteristics as related to colour-mixer characteristics<br>(3) Test for O's head speed & accuracy using training programme without filters | 22                     | 2.76                               |
| 3           | 2               |                                                                                                                                                                                                             | 29                     | 2.02                               |
| 4           | 3               | (1) O's hue responses through filters<br>(2) Gaze-contingent hue-shift after-effect                                                                                                                         |                        |                                    |
| 6           | 5               |                                                                                                                                                                                                             | 22                     | 1.07                               |
| 7           | 6               |                                                                                                                                                                                                             | 16                     | .63                                |
| 8           | 7               |                                                                                                                                                                                                             | 26                     | 1.01                               |
| 9           | 8               | Computer-controlled comparison test (with feedback)                                                                                                                                                         | 14                     | .61                                |
| 13          | 12              | Comparison test (without feedback)                                                                                                                                                                          |                        |                                    |
| 14          | 13              | Comparison test (without feedback)                                                                                                                                                                          | 14                     | 1.13                               |
| 15          | 14              |                                                                                                                                                                                                             | 16                     | 1.22                               |
| 16          | 15              |                                                                                                                                                                                                             | 17                     | 1.04                               |
| 17          | 16              |                                                                                                                                                                                                             | 15                     | .87                                |
| 20          | 19              |                                                                                                                                                                                                             | 20                     | .94                                |
| 21          | 20              |                                                                                                                                                                                                             | 15                     | .66                                |
| 22          | 21              | Hue-labelling                                                                                                                                                                                               |                        |                                    |
| 23          | 22              | Hue-labelling                                                                                                                                                                                               |                        |                                    |
| 24          | 23              | (1) Gaze-contingent hue-shift after-effect<br>(2) Laterality bias in system                                                                                                                                 |                        |                                    |
| 28          | 27              | (1) Tone-contingent hue-shift<br>(2) Gaze-contingent hue-shift<br>(3) Gaze-contingent hue-shift without tones                                                                                               |                        |                                    |
| April 26    | 55              | Test for extinction                                                                                                                                                                                         |                        |                                    |

CONDITIONING OF GAZE-CONTINGENT  
HUE RESPONSES

DIARY OF TRAINING AND TESTING SESSIONS

SUBJECT: Kathryn

| <u>Date</u> | <u>Exp.<br/>Day</u> | <u>Testing Sessions</u>                                                                                      | <u>Training</u>            |                                             |
|-------------|---------------------|--------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------|
|             |                     |                                                                                                              | <u>No. of<br/>Sessions</u> | <u>Total<br/>Duration<br/>(Nett)</u><br>hrs |
| April 7     | 1                   | (Pre-training <u>control</u> sessions)                                                                       | 8                          | .85                                         |
| 10          | 4                   | Do.                                                                                                          | 11                         | .95                                         |
| 11          | 5                   | Do.                                                                                                          | 6                          | 1.35                                        |
| 12          | 6                   | Do.                                                                                                          | 6                          | 1.13                                        |
| 14          | 8                   | Do.                                                                                                          | 4                          | 1.32                                        |
| 17          | 11                  | (1) Gaze-contingent hue responses<br>(2) Laterality bias in viewing system                                   |                            |                                             |
| 18          | 12                  |                                                                                                              | 19                         | 1.99                                        |
| 20          | 14                  |                                                                                                              | 6                          | .41                                         |
| 21          | 15                  |                                                                                                              | 11                         | .86                                         |
| 24          | 18                  |                                                                                                              | 11                         | .64                                         |
| 25          | 19                  |                                                                                                              | 9                          | .62                                         |
| 27          | 21                  |                                                                                                              | 8                          | .57                                         |
| 28          | 22                  |                                                                                                              | 12                         | .95                                         |
| 29          | 23                  | (1) Gaze-contingent hue-shift after-effect<br>(2) Laterality bias in viewing system                          |                            |                                             |
| May 8       | 32                  |                                                                                                              | 15                         | .73                                         |
| 9           | 33                  |                                                                                                              | 11                         | .52                                         |
| 10          | 34                  |                                                                                                              | 3                          | .15                                         |
| 12          | 36                  |                                                                                                              | 12                         | .57                                         |
| 15          | 39                  |                                                                                                              | 13                         | .64                                         |
| 16          | 40                  |                                                                                                              | 11                         | .53                                         |
| 17          | 41                  |                                                                                                              | 9                          | .45                                         |
| 18          | 42                  |                                                                                                              | 9                          | .50                                         |
| 19          | 43                  |                                                                                                              | 11                         | .60                                         |
| 22          | 46                  |                                                                                                              | 11                         | .57                                         |
| 23          | 47                  |                                                                                                              | 11                         | .54                                         |
| 24          | 48                  | (1) Gaze-contingent hue-shift after-effect<br>(2) Gaze-forward (no tones) hue responses                      |                            |                                             |
| 25          | 49                  | (1) Gaze-contingent hue shift <u>without</u> tones<br>(2) <u>Tone</u> -contingent shift without head-turning |                            |                                             |
| 26          | 50                  | (1) Gaze-and-tone-contingent hue shift<br>(2) Do. (without mirrors)                                          |                            |                                             |
| 29          | 53                  | Gaze-and-tone-contingent hue shift<br>(with mirrors)                                                         |                            |                                             |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSIONS

All testing sessions were conducted in a darkened room (the same as that used for the experimental sessions). A period of approximately 5 minutes was allowed for dark-adaptation before each session. When more than one session was scheduled, or when a session had proceeded for about 20 minutes, at least 10 minutes was set aside as a rest interval before further testing.

Two general methods were adopted, but variations on each make it difficult to summarise the trend of the testing sessions as a whole. In the case of the first subject, Paula, the method principally used was that of single stimuli, in steps of decreasing hue contrast. A forced-choice response was required ("red" or "green"), with guessing permitted when judgments became too difficult. The method of adjustment was also used with this subject, but not as extensively as with the second subject, Kathryn. In the latter case, an important innovation was to expose the test field intermittently (4 secs. on and 4 secs. off) while the subject was in the process of obtaining her neutral point. These interruptions were under computer control.

For characteristics of colour-mixers, including chromaticities and luminances, see Appendix 1, p.246f.

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSIONS

Data Sheet: 1

Subject: Paula Date: 2 March Time: 2 p.m. Day No: 1

Serial Status of Test: Pre-experimental

Purpose: Informal testing for laterality bias in viewing system

Method of Single Stimuli, open-ended judgements

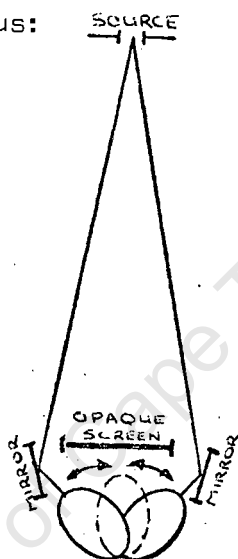
Viewing Conditions: Oblique viewing angles. Via mirrors (M)

Head Movements, left or right, randomly alternated.

Viewing Time per Stimulus: SOURCE  
+ 2secs.Interval between  
Stimuli: +10 secs.

No tones

Filters removed

(0 = Max. Red  
100 = Max. Blue-  
green)

Two-colour mixer

2° circular field

Luminance: See p. 246a.

Settings via vernier dial

Range: 45-60, but 52-54  
omitted in error, 56-59  
omitted deliberately.Sequence of presentations:  
In steps of decreasing hue  
contrast

| Vernier<br>Settings | Direction<br>of<br>Gaze | O's Open-ended Verbal Responses |                 |
|---------------------|-------------------------|---------------------------------|-----------------|
|                     |                         | First Sequence                  | Second Sequence |
| 45.0                | L                       | pink                            | pink            |
| 60.0                | L                       | green                           | green           |
| 46.0                | R                       | pink                            | pink            |
| 55.0                | R                       | green                           | green           |
| 60.0                | R                       | green                           | green           |
| 45.0                | R                       | pink                            | pink            |
| 55.0                | L                       | green                           | green           |
| 46.0                | L                       | pink                            | pink            |
| 47.0                | L                       | pinkish                         | pink            |
| 53.0                | R                       | green                           | green           |
| 47.0                | R                       | very pale pink                  | pink            |
| 53.0                | L                       | green                           | green           |
| 48.0                | R                       | pinky grey                      | pale pink       |
| 49.0                | L                       | neither - very slightly green   | very pale green |
| 49.0                | R                       | neither                         | greyish         |
| 48.0                | L                       | neither                         | grey?           |
| 50.0                | L                       | greenish                        | greenish        |
| 51.0                | R                       | grey?                           | grey?           |
| 50.0                | R                       | neither                         | grey            |
| 51.0                | L                       | green                           | very pale green |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSIONS

Data Sheet: 2

Subject: Paula Date: 2 March Time: Not Recorded Day No: 1

Serial Status of Test: Pre-experimental

Purpose: To relate characteristics of viewing filters used to colour characteristics.

Method of Stimuli, open-ended judgements

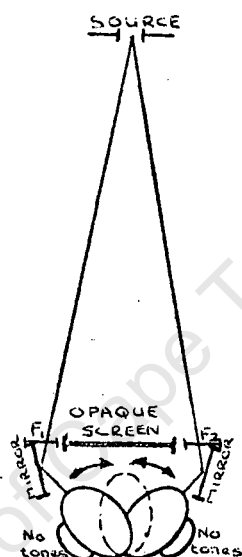
Viewing Conditions: Oblique viewing angles

Via Mirrors (M)

Head Movements: left only in one series, then right only in one series (Head-phones worn) (no tones)

Viewing Time: per stimulus +2 secs.

Interval between stimuli: +10 secs.

Filters ( $F_1$  &  $F_2$ ) in pos.

Two-colour mixer

2° circular field

Luminance: See p. 246a.

Settings via vernier dial

Range: 25-75

Sequence of presentations: Random

 $F_1$  = Red $F_2$  = Blue-Green(0 = Max. Red  
100 = Max. Blue-Green)

## O's Open-ended Verbal Responses

| Vernier Settings | Viewing                                                 | First Sequence  | Second Sequence |
|------------------|---------------------------------------------------------|-----------------|-----------------|
| 65.0             | Gaze-left through RED viewing filter (No tones)         | pinkish grey    | pinkish         |
| 75.0             |                                                         | green-grey      | greenish        |
| 67.0             |                                                         | pinkish grey    | pinkish         |
| 74.0             |                                                         | green-grey      | greenish        |
| 69.0             |                                                         | pinkish greyish | pinkish         |
| 73.0             |                                                         | green-grey      | greenish        |
| 70.0             |                                                         | grey            | grey            |
| 72.0             |                                                         | grey            | grey            |
| 25.0             | Gaze-right through BLUE-GREEN viewing filter (No tones) | pinkish         | pink            |
| 38.0             |                                                         | greenish        | greenish        |
| 29.0             |                                                         | pinkish grey    | pinkish         |
| 37.0             |                                                         | greenish grey   | more greenish   |
| 30.0             |                                                         | pinkish         | pinkish grey    |
| 35.0             |                                                         | grey            | grey            |
| 32.0             |                                                         | greyish         | grey            |
| 33.0             |                                                         | grey?           | difficult-pink? |



CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSIONS

Data Sheet: 2A

Subject: Paula Date: 2 March Time:

Day No: 1

Serial Status of Test: Pre-experimental

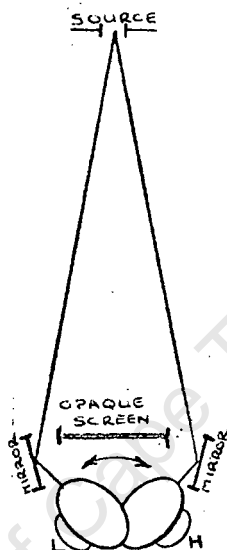
Purpose: To obtain criteria of speed and accuracy which could be imposed on Q during the training phase.

Method of Paired Comparisons; responses 'same' or 'different'

Viewing Conditions: Oblique viewing angles Via Mirrors (M)

Head movements ad lib,  
inspection of each of  
given pair of colour-  
stimuli. Responses  
made by key-pressing;  
left for 'same', right  
for 'different',  
feedback on 100%  
+ve & -ve  
schedule.

Headphones worn;  
Low tone(260 Hz)  
in left ear;  
High tone(390 Hz)  
in right ear, on  
gaze-left & gaze-  
right respectively.  
No filters.



Three-colour mixer

2° circular field

Luminances: See p. 247.

Pairs of colours presented  
by computer; first of pair  
seen only on gaze-left;  
second only on gaze-right.

Random selection from 9  
colours available.

| Session No. | No. of Trials Per Session | No. of Errors per Session | Mean Reaction Time (seconds) |
|-------------|---------------------------|---------------------------|------------------------------|
| 1           | 72                        | 3                         | 3.79                         |
| 2           | 72                        | 2                         | 2.80                         |
| 3           | 72                        | 1                         | 2.68                         |
| 4           | 72                        | 4                         | 2.77                         |

N.B. Session showing best performance on both accuracy and speed was no.3, yielding a "performance index" (= errors x RT) of 2.7, which was adopted as Q's target or criterion.

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

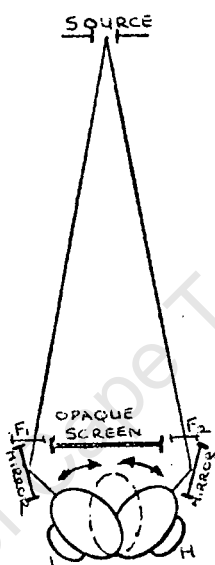
Data Sheet: 3

Subject: Paula Date: 4 March Time: Not recorded Day No: 3

Serial Status of Test: After first experimental phase, 67 sessions,  
4824 trials, 5.74 hours, over 3 daysPurpose: To establish the nature and extend of hue-shift with  
viewing filters in position.

Method of Single Stimuli, Dichotomous (R/G) Responses.

Viewing Conditions: Oblique viewing angles Via Mirrors (M)

Head movements, left and  
right alternately in one  
series per sequence  
viewing time per stimulus:  
+2 secs.Interval between stimuli:  
+10 secs.Filters in position,  
F<sub>1</sub> = RED, F<sub>2</sub> = BLUE-GREENHeadphones worn;  
Low tone (260 Hz) in  
left ear on gaze-  
left; High tone  
(390 Hz) in right  
ear on gaze-  
right.

Two-colour mixer

2° circular field

Luminance: See p. 246a.

Settings via vernier dial

Range: 29-37; 62-70

Sequence of presentation  
in steps of decreasing  
hue contrast(0 = Max. RED, 100 =  
Max. BLUE-GREEN)

| Vernier<br>Settings | Direction<br>of<br>Gaze | O's Verbal Responses<br>Sequences |   |   |   |   |   |
|---------------------|-------------------------|-----------------------------------|---|---|---|---|---|
|                     |                         | 1                                 | 2 | 3 | 4 | 5 | 6 |
| 70.0                | L                       | G                                 | G | G | G | G | G |
| 29.0                | R                       | R                                 | R | R | R | R | R |
| 69.0                | L                       | G                                 | G | G | G | G | G |
| 30.0                | R                       | R                                 | R | R | R | R | R |
| 68.0                | L                       | G                                 | G | G | G | G | G |
| 31.0                | R                       | R                                 | R | R | R | R | R |
| 67.0                | L                       | G                                 | R | G | G | G | G |
| 32.0                | R                       | R                                 | R | G | R | G | R |
| 66.0                | L                       | G                                 | R | G | G | G | R |
| 33.0                | R                       | R                                 | G | G | R | R | G |
| 65.0                | L                       | R                                 | R | G | R | R | R |
| 34.0                | R                       | G                                 | G | R | G | G | G |
| 64.0                | L                       | R                                 | R | R | R | R | R |
| 35.0                | R                       | R                                 | G | G | G | G | G |
| 63.0                | L                       | R                                 | R | R | R | R | R |
| 36.0                | R                       | G                                 | G | G | G | G | G |
| 62.0                | L                       | R                                 | R | R | R | R | R |
| 37.0                | R                       | G                                 | G | G | G | G | G |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 4    Date: 4 March    Time: Not recorded    Day No: 3

Subject: Paula    Serial Status of Test: After first training phase comprising 5.74 hours (67 sessions, 4824 trials) over 3 days.

Purpose: To establish nature and extent of gaze-contingent hue shift as after-effect (i.e. without filters)

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: Oblique viewing angles    Via Mirrors(M)

Head movements, random alternations of left and right.

Viewing time per stimulus:

+1 sec. Interval between

stimuli: +10 sec. Red

filter during training

in gaze-left path; Blue-

Green filter during

training in gaze-right

path.

Headphones worn;

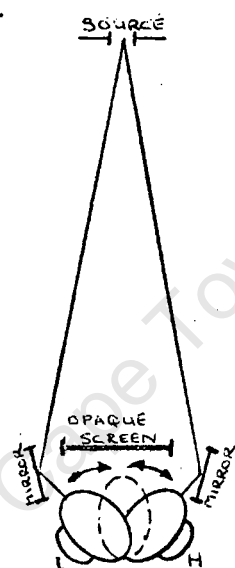
Low tone(260 Hz) in

left ear on gaze-

left; High tone

(390 Hz) in right

ear on gaze-right.



Two-colour mixer

2°circular field

Luminance: See p. 246a.

Settings via vernier dial. Range: 45-55

Sequence of presentation in steps of decreasing hue contrast.

Filters removed

| Vernier Settings | Direction of Gaze | O's Verbal Responses |   |   |   |   |   |
|------------------|-------------------|----------------------|---|---|---|---|---|
|                  |                   | Sequences            |   |   |   |   |   |
|                  |                   | 1                    | 2 | 3 | 4 | 5 | 6 |
| 45.0             | L                 | R                    | R | R | R | R | R |
| 55.0             | R                 | G                    | G | G | G | G | G |
| 45.0             | R                 | R                    | R | R | R | R | R |
| 55.0             | L                 | G                    | G | G | G | G | G |
| 46.0             | L                 | R                    | R | R | R | R | R |
| 54.0             | R                 | G                    | G | G | G | G | G |
| 46.0             | L                 | R                    | R | R | R | R | R |
| 54.0             | R                 | G                    | G | G | G | G | G |
| 47.0             | R                 | R                    | R | R | R | R | R |
| 53.0             | R                 | G                    | G | R | R | G | G |
| 47.0             | L                 | R                    | R | R | R | R | R |
| 53.0             | L                 | G                    | G | G | G | G | G |
| 48.0             | L                 | G                    | G | R | G | R | R |
| 52.0             | L                 | G                    | G | G | G | G | G |
| 48.0             | R                 | R                    | R | R | R | R | R |
| 52.0             | R                 | G                    | G | R | G | G | R |
| 49.0             | L                 | G                    | R | R | R | G | R |
| 51.0             | R                 | R                    | R | R | R | R | R |
| 49.0             | R                 | R                    | R | R | R | R | R |
| 51.0             | L                 | G                    | G | R | R | G | G |
| 50.0             | L                 | G                    | R | G | G | R | R |
| 50.0             | R                 | R                    | R | R | R | R | R |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 4A Date: 13 March Time: Not recorded Day No: 12

Subject: Paula Serial Status of Test: 4 days after completion of 145 sessions (10,440 trials) of training comprising 9.06 hours over 7 days.

Purpose: To obtain qualitative evidence of nature and direction of after-effect gaze-contingent hue shift.

Method of Paired Comparisons; responses "same" or "different"

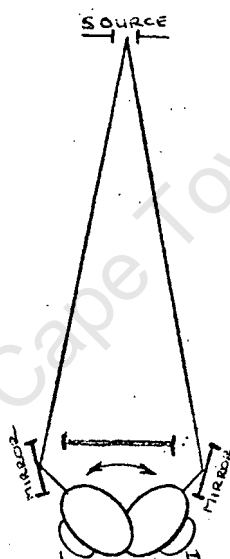
Viewing Conditions: Oblique viewing angles Via Mirrors(M)

Head movements ad-lib, inspection of each of given pair of colour-stimuli. Responses made by key-pressing; left key for "same"; right key for "different".

No feedback

Headphones worn; low tone (260 Hz) in left ear; High tone (390 Hz) in right ear on gaze-left and gaze-right respectively.

Red filter during training in gaze-left path; Blue-green filter during training in gaze-right path.



Three-colour mixer

2° circular field

Luminances: See p. 247.

Pairs of colours presented by computer; first of pair seen only on gaze-left; second only on gaze-right.

Random selection of pairs from 9 colours available

No filters

| Sessions<br>(72 trials ea.) | "Match"<br>Errors | "Mismatch"<br>Errors | Total<br>Errors | Mean RT<br>(seconds) |
|-----------------------------|-------------------|----------------------|-----------------|----------------------|
| 1                           | 15                | 1                    | 16              | 2.73                 |
| 2                           | 17                | 0                    | 17              | 2.58                 |
| 3                           | 18                | 0                    | 18              | 2.57                 |
| 4                           | 17                | 0                    | 17              | 2.13                 |
| 5                           | 20                | 0                    | 20              | 2.49                 |
| 6                           | 16                | 0                    | 16              | 2.11                 |
| 7                           | 19                | 1                    | 20              | 2.37                 |
| 8                           | 18                | 0                    | 18              | 2.00                 |
| 9                           | 17                | 0                    | 17              | 2.10                 |
| 10                          | 22                | 1                    | 23              | 2.13                 |
| Totals: 720<br>trials       | 179               | 3                    | 182             | Mean: 2.32           |

N.B. O Spontaneously reported that "certain of the colours looked pinker on the right-hand side than on the left-hand side".

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 4B Date: 14 March Time: Not recorded Day No: 13

Subject: Paula Serial Status of Test; 4 days after completion of 145 sessions (10,440 trials) of training comprising 9.06 hours over 7 days.

Purpose: To obtain qualitative evidence of nature and direction of after-effect gaze-contingent hue shift.

Method of Paired Comparisons; responses "same" or "different"

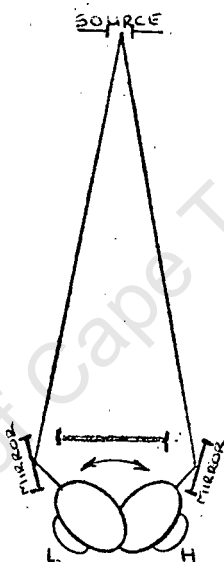
Viewing Conditions: Oblique viewing angles via mirrors(M)

Head movements ad-lib, inspection of each of given pair of colour-stimuli. Responses made by key-pressing; left key for "same"; right key for "different".

No feedback.

Headphones worn; low tone (260 Hz) in left ear; High tone (390 Hz) in right ear on gaze-left and gaze-right respectively.

Red filter during training in gaze-left path; Blue-Green filter during training in gaze-right path.



Three-colour mixer

2° circular field

Luminances: See p. 247.

Pairs of colours presented by computer; first of pair seen only on gaze-left; second only on gaze-right.

Random selection of pairs from 9 colours available.

No filters.

| Sessions<br>(72 trials ea.) | "Match"<br>Errors | "Mismatch"<br>Errors | Total<br>Errors | Mean RT<br>(seconds) |
|-----------------------------|-------------------|----------------------|-----------------|----------------------|
| 1                           | 15                | 1                    | 16              | 13.27                |
| 2                           | 16                | 2                    | 18              | 14.95                |
| 3                           | 16                | 2                    | 18              | 3.16                 |
| Totals: 216<br>trials       | 47                | 5                    | 52              | 10.46                |

N.B. In this case Q was especially asked to make judgements concerning the laterality differences in the pairs of colours presented. After these sessions, she reported without any hesitation that pairs of colours which she knew "were supposed to be the same" (i.e. actual matches) did not appear the same, and repeated that "some of them look pinker on the right-hand side than on the left-hand side".

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: TESTING SESSIONS  
(Culled from computer printout)

Subject: Paula (cont)

Data Sheet 4C

Special Hue-Labeling Test

| DATE     | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX:<br>MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES |
|----------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|----------------------------------------------|---------------------|
| 22 March | 21      |             |                         | D                  | 0                     | 7                        | 7            | 7.63                         | 9.20                                    | 612                          |                                              |                     |
|          |         |             |                         |                    | 2                     | 2                        | 4            | 6.33                         | 8.94                                    | 592                          |                                              |                     |
|          |         |             |                         |                    | 2                     | 1                        | 3            | 5.67                         | 4.00                                    | 420                          |                                              |                     |
|          |         |             |                         |                    | 0                     | 5                        | 5            | 5.50                         | 1.88                                    | 405                          |                                              | .56 hours           |
| 23 March | 22      |             |                         | D                  | 2                     | 5                        | 7            | 5.98                         | 15.62                                   | 540                          |                                              |                     |
|          |         |             |                         |                    | 0                     | 6                        | 6            | 4.57                         | 10.36                                   | 389                          |                                              |                     |
|          |         |             |                         |                    | 1                     | 1                        | 2            | 4.87                         | 21.70                                   | 394                          |                                              |                     |
|          |         |             |                         |                    | 1                     | 2                        | 3            | 5.09                         | 14.64                                   | 409                          |                                              |                     |
|          |         |             |                         |                    | 3                     | 0                        | 3            | 5.86                         | 18.87                                   | 479                          |                                              |                     |
|          |         |             |                         |                    | 1                     | 3                        | 4            | 5.19                         | 6.18                                    | 399                          |                                              |                     |
|          |         |             |                         |                    | 1                     | 1                        | 2            | 5.56                         | 5.76                                    | 411                          |                                              |                     |
|          |         |             |                         |                    | 0                     | 1                        | 1            | 5.08                         | 8.40                                    | 374                          |                                              |                     |
|          |         |             |                         |                    | 2                     | 1                        | 3            | 4.92                         | 1.98                                    | 360                          |                                              |                     |
|          |         |             |                         |                    | 0                     | 6                        | 6            | 4.70                         | 8.28                                    | 387                          |                                              | 1.15 hours          |



# CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 6 Date: 24 March Time: 3 p.m. Day No: 23

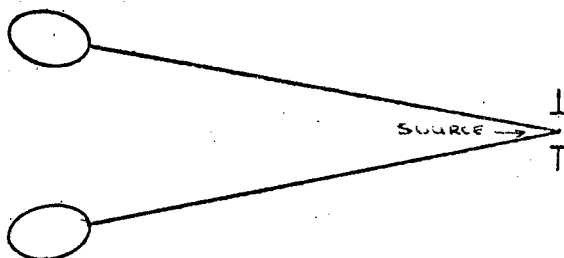
Subject: Paula Serial Status of Test: See Data Sheet 5

Purpose: To establish nature and extent of laterality bias in system

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: No mirrors, oblique viewing angles, no head movements, no headphones, no tones.

Left path in one series; Right path in one series. Viewing time per stimulus: 1 sec. Interval betw. stimuli: +10 sec. (0=Max. Red; 100=Max. Blue-Green)



Range of vernier settings: 42-58

Sequence of presentation in steps of decreasing hue contrast.

| Vernier Setting | Viewing                                 | O's Verbal Response Sequences |   |   |   |   |   |   |   |
|-----------------|-----------------------------------------|-------------------------------|---|---|---|---|---|---|---|
|                 |                                         | 1                             | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 58.0            | Gaze-forward, in "left" (oblique) path  | G                             | G | G | G | G | G | G | G |
| 42.0            |                                         | R                             | R | R | R | R | R | R | R |
| 57.0            |                                         | G                             | G | G | G | G | G | G | G |
| 43.0            |                                         | R                             | R | R | R | R | R | R | R |
| 56.0            |                                         | G                             | G | G | G | G | G | G | G |
| 44.0            |                                         | R                             | R | R | R | R | R | R | R |
| 55.0            |                                         | G                             | G | G | G | G | G | G | G |
| 45.0            |                                         | R                             | R | R | R | R | R | R | R |
| 54.0            |                                         | G                             | G | G | G | G | G | G | G |
| 46.0            |                                         | R                             | R | R | R | R | R | R | R |
| 53.0            |                                         | G                             | G | G | G | G | G | G | G |
| 47.0            |                                         | R                             | R | R | R | R | R | R | R |
| 52.0            |                                         | G                             | G | G | G | G | G | G | G |
| 48.0            |                                         | R                             | R | R | R | R | R | R | R |
| 51.0            |                                         | G                             | G | G | G | G | G | G | G |
| 49.0            |                                         | R                             | R | R | R | R | R | R | R |
| 50.0            |                                         | G                             | G | G | G | G | G | G | G |
| 58.0            | Gaze-forward, in "right" (oblique) path | G                             | G | G | G | G | G | G | G |
| 42.0            |                                         | R                             | R | R | R | R | R | R | R |
| 57.0            |                                         | G                             | G | G | G | G | G | G | G |
| 43.0            |                                         | R                             | R | R | R | R | R | R | R |
| 56.0            |                                         | G                             | G | G | G | G | G | G | G |
| 44.0            |                                         | R                             | R | R | R | R | R | R | R |
| 55.0            |                                         | G                             | G | G | G | G | G | G | G |
| 45.0            |                                         | R                             | R | R | R | R | R | R | R |
| 54.0            |                                         | G                             | G | G | G | G | G | G | G |
| 46.0            |                                         | R                             | R | R | R | R | R | R | R |
| 53.0            |                                         | G                             | G | G | G | G | G | G | G |
| 47.0            |                                         | R                             | R | R | R | R | R | R | R |
| 52.0            |                                         | G                             | G | G | G | G | G | G | G |
| 48.0            |                                         | R                             | R | R | R | R | R | R | R |
| 51.0            |                                         | G                             | G | G | G | G | G | G | G |
| 49.0            |                                         | R                             | R | R | R | R | R | R | R |
| 50.0            |                                         | G                             | G | G | G | G | G | G | G |

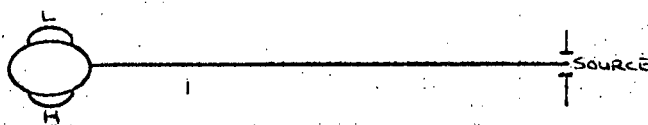


# CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 7 Date: 28 March Time: 2 p.m. Day No: 27  
 Subject: Paula Serial Status of Test: 7 days after complete training programme.

Purpose: To establish whether a purely tone-contingent shift in hue perception had occurred, and if so, its nature and extent.

Method of Single Stimuli, Dichotomous (R/G) Responses



Viewing Conditions: No mirrors,  
 Viewing angle perpendicular to  
 colour-mixer, No head movements,  
 Viewing time per stimulus: +1 sec.  
 Interval between stimuli: +10 sec.  
 Eyes shut between presentations.  
 Headphones worn, low tone (260 Hz)  
 in left ear randomly alternated  
 with High tone (390 Hz) in right  
 ear.

Two-colour mixer

2° circular field

Luminance: See p. 246 a.

Settings via vernier  
 dial, range: 44-56

Sequence of presentation  
 in decreasing order of  
 hue-contrast.

| Vernier<br>Setting | Tones | O's Verbal Responses<br>Sequences |   |   |   |   |   |   |   |
|--------------------|-------|-----------------------------------|---|---|---|---|---|---|---|
|                    |       | 1                                 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 56.0               | low   | G                                 | G | G | G | G | G | G | G |
| 44.0               | high  | R                                 | R | R | R | R | R | R | R |
| 56.0               | high  | G                                 | G | G | G | G | G | G | G |
| 44.0               | low   | R                                 | R | R | R | R | R | R | R |
| 55.0               | low   | G                                 | G | G | G | G | G | G | G |
| 45.0               | low   | R                                 | R | R | R | R | R | R | R |
| 55.0               | high  | G                                 | G | G | G | G | G | G | G |
| 45.0               | high  | R                                 | R | R | R | R | R | R | R |
| 54.0               | low   | G                                 | G | G | G | G | G | G | G |
| 46.0               | high  | R                                 | R | R | R | R | R | R | R |
| 54.0               | high  | G                                 | G | G | G | G | G | G | G |
| 46.0               | low   | R                                 | R | R | R | R | R | R | R |
| 53.0               | low   | G                                 | G | G | G | G | G | G | G |
| 47.0               | high  | R                                 | R | R | R | R | R | R | R |
| 53.0               | high  | G                                 | G | G | G | G | G | G | G |
| 47.0               | low   | R                                 | R | R | R | R | R | R | R |
| 52.0               | high  | G                                 | G | G | G | G | G | G | G |
| 48.0               | low   | R                                 | G | R | R | R | R | R | R |
| 52.0               | low   | G                                 | G | R | G | G | G | G | G |
| 48.0               | high  | R                                 | R | R | R | R | R | R | R |
| 51.0               | high  | R                                 | R | R | R | G | R | R | G |
| 49.0               | high  | R                                 | R | R | R | R | R | R | R |
| 51.0               | low   | R                                 | R | G | R | G | G | G | G |
| 49.0               | low   | R                                 | R | R | R | R | R | R | R |
| 50.0               | high  | R                                 | R | R | R | R | R | R | G |
| 50.0               | low   | G                                 | R | R | R | R | G | R | G |

# CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 8    Date: 28 March    Time: 3 p.m.    Day No: 27

Subject: Paula    Serial Status of Test: 7 days after complete training programme.

Purpose: To establish nature and extent of gaze-contingent hue-shift without use of mirrors.

Method of Adjustment for Subjective Neutral Point

Two-colour mixer, settings via vernier dial (0 = Max. Red; 100 = Max. Blue-Green)    2° circular test-field

Viewing conditions: No mirrors. Viewing angle perpendicular to mixer. Head-movements only at the beginning of each adjustment period, which took about 15 seconds each. Left only in one series; followed by right only in one series. Stimuli switched on by O's head-movements, via computer programme. Headphones worn. Low tone (260 Hz) in left ear gaze-left; High tone (390 Hz) in right ear, gaze-right. Eyes shut between presentations. Mixer adjusted by E to about 10 units alternately "lower" and "higher" than O's neutral setting in successive trials.



| Raw Data  |                              |                 | Viewing: Left |                              | Viewing: Right  |  |
|-----------|------------------------------|-----------------|---------------|------------------------------|-----------------|--|
| Trial No. | Initial Colour-Mixer Setting | Vernier Reading |               | Initial Colour-Mixer Setting | Vernier Reading |  |
| 1         | G                            | 46.0            |               | R                            | 48.8            |  |
| 2         | R                            | 47.0            |               | G                            | 48.6            |  |
| 3         | G                            | 45.9            |               | R                            | 48.0            |  |
| 4         | R                            | 48.0            |               | G                            | 46.0            |  |
| 5         | G                            | 46.0            |               | R                            | 45.5            |  |
| 6         | R                            | 45.5            |               | G                            | 47.0            |  |
| 7         | G                            | 44.1            |               | R                            | 45.0            |  |
| 8         | R                            | 44.1            |               | G                            | 45.0            |  |
| 9         | G                            | 42.5            |               | R                            | 44.9            |  |
| 10        | R                            | 44.0            |               | G                            | 48.0            |  |
| 11        | G                            | 43.7            |               | R                            | 46.4            |  |
| 12        | R                            | 41.8            |               | G                            | 47.0            |  |
| 13        | G                            | 47.0            |               | R                            | 50.9            |  |
| 14        | R                            | 41.1            |               | G                            | 47.2            |  |
| 15        | G                            | 44.1            |               | R                            | 46.8            |  |
| 16        | R                            | 44.2            |               | G                            | 44.9            |  |
| 17        | G                            | 42.5            |               | R                            | 49.3            |  |
| 18        | R                            | 42.2            |               | G                            | 49.0            |  |
| 19        | G                            | 47.4            |               | R                            | 46.2            |  |
| 20        | R                            | 45.0            |               | G                            | 50.0            |  |

# CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

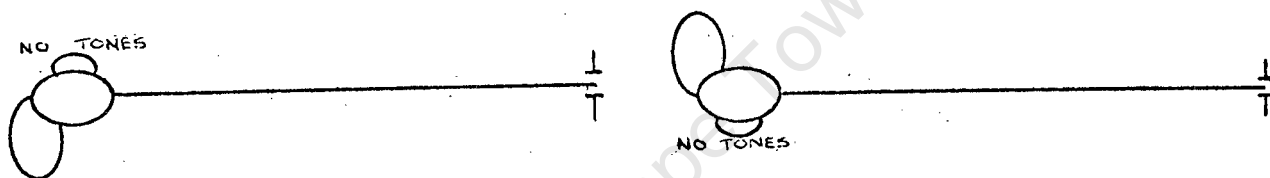
Data Sheet: 9 Date: 28 March Time: 4 p.m. Day: 27

Subject: Paula Special Status of Test: 7 days after complete training programme.

Purpose: To establish the nature and extent of gaze-contingent shift without tones in ears.

Method of Adjustment for Subjective Neutral Point: Two-colour mixer, settings via vernier dial (0 = Max. Red; 100 = Max. Blue-Green) 2° circular test field.

Viewing Conditions: No mirrors. Viewing angle perpendicular to mixer. Head movements only at beginning of each adjustment period, which took about 15 seconds each. Left only in one series, followed by right only in one series. Stimuli switched on by O's head-movements, via computer programme. Headphones worn, but no tones in ears. Eyes shut between presentations. Mixer adjusted by E to about 10 units alternately 'lower' and 'higher' than O's neutral setting, in successive trials.



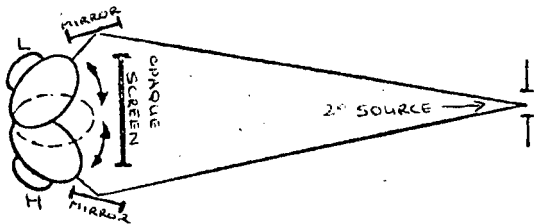
| Raw Data  | Viewing: Left                |                 | Viewing: Right               |                 |
|-----------|------------------------------|-----------------|------------------------------|-----------------|
| Trial No. | Initial Colour-Mixer Setting | Vernier Reading | Initial Colour-Mixer Setting | Vernier Reading |
| 1         | G                            | 45.0            | R                            | 46.8            |
| 2         | R                            | 43.8            | G                            | 47.2            |
| 3         | G                            | 45.5            | R                            | 44.3            |
| 4         | R                            | 44.1            | G                            | 45.6            |
| 5         | G                            | 45.4            | R                            | 46.4            |
| 6         | R                            | 44.2            | G                            | 44.4            |
| 7         | G                            | 44.4            | R                            | 46.0            |
| 8         | R                            | 40.2            | G                            | 44.3            |
| 9         | G                            | 46.3            | R                            | 49.5            |
| 10        | R                            | 41.3            | G                            | 48.7            |
| 11        | G                            | 44.2            | R                            | 44.3            |
| 12        | R                            | 42.3            | G                            | 42.2            |
| 13        | G                            | 43.1            | R                            | 42.4            |
| 14        | R                            | 43.9            | G                            | 43.2            |
| 15        | G                            | 47.5            | R                            | 45.1            |
| 16        | R                            | 45.2            | G                            | 49.0            |
| 17        | G                            | 44.6            | R                            | 43.0            |
| 18        | R                            | 41.5            | G                            | 43.2            |
| 19        | G                            | 41.5            | R                            | 42.0            |
| 20        | R                            | 39.0            | G                            | 46.0            |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: TESTING SESSION(S)

Data Sheet: 10    Date: 26 April    Time: 2 p.m.    Day: 55  
Subject: Paula    Serial Status of Test: 35 days after completion of training programme.

Purpose: To establish whether extinction of gaze-contingent hue shift had set in.

Method of Single Stimuli, Dichotomous (R/G) Responses



| Vernier Settings | Direction of Gaze | O's Verbal Responses |   |   |   |   |   |   |   |
|------------------|-------------------|----------------------|---|---|---|---|---|---|---|
|                  |                   | Sequences            |   |   |   |   |   |   |   |
|                  |                   | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 58.0             | L                 | G                    | G | G | G | G | G | G | G |
| 42.0             | R                 | R                    | R | R | R | R | R | R | R |
| 58.0             | R                 | G                    | G | G | G | G | G | G | G |
| 42.0             | L                 | R                    | R | R | R | R | R | R | R |
| 57.0             | L                 | G                    | G | G | G | G | G | G | G |
| 43.0             | R                 | R                    | R | R | R | R | R | R | R |
| 57.0             | R                 | G                    | G | G | G | G | G | G | G |
| 43.0             | L                 | R                    | R | R | R | R | R | R | R |
| 56.0             | L                 | G                    | G | G | G | G | G | G | G |
| 44.0             | R                 | R                    | R | R | R | R | R | R | R |
| 56.0             | R                 | G                    | G | G | G | G | G | G | G |
| 44.0             | L                 | R                    | R | R | R | R | R | R | R |
| 55.0             | R                 | G                    | G | G | G | G | G | G | G |
| 45.0             | L                 | R                    | R | R | R | R | R | R | R |
| 55.0             | L                 | G                    | G | G | G | G | G | G | G |
| 45.0             | R                 | R                    | R | R | R | R | R | R | R |
| 54.0             | L                 | G                    | G | G | G | G | G | G | G |
| 46.0             | R                 | R                    | R | R | R | R | R | R | R |
| 54.0             | R                 | G                    | G | G | G | G | G | G | G |
| 46.0             | L                 | R                    | R | R | R | R | R | R | R |
| 53.0             | L                 | G                    | G | G | G | G | G | G | G |
| 47.0             | R                 | R                    | R | R | R | R | R | R | R |
| 53.0             | R                 | G                    | G | G | G | G | G | G | G |
| 47.0             | L                 | R                    | R | R | R | R | R | R | R |
| 52.0             | R                 | G                    | R | R | G | G | G | G | G |
| 48.0             | L                 | R                    | R | R | R | G | G | G | G |
| 52.0             | L                 | G                    | G | G | G | G | G | G | G |
| 48.0             | R                 | R                    | R | R | R | G | R | R | R |
| 51.0             | R                 | G                    | G | G | R | G | G | G | G |
| 49.0             | L                 | R                    | R | R | G | R | R | G | G |
| 51.0             | L                 | G                    | G | G | G | G | G | G | G |
| 49.0             | R                 | R                    | R | R | R | G | R | G | R |
| 50.0             | L                 | G                    | G | G | G | G | R | G | G |
| 50.0             | R                 | R                    | R | G | R | G | G | R | G |

# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 1 Date: 17 April Time: 2 p.m. Day No: 11

Subject: Kathryn Serial Status of Test: 3 days after control sessions, total viewing time 5.6 hours.

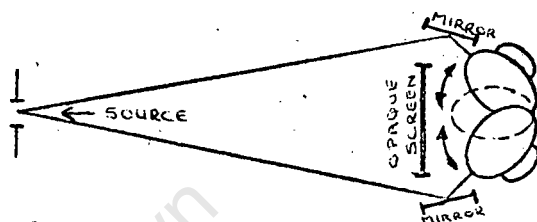
Purpose: To establish nature and extent of gaze-contingent hue-shift as a result of control sessions.

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: As for Paula, Data Sheet 4, except that Red filter during training in gaze-right path; Blue-Green filter during training in gaze-left path.

Range of vernier settings: 42-58

(0 = Max. Red; 100 = Max. Blue-Green)



| Vernier Settings | Direction of Gaze | O's Verbal Responses Sequences |   |   |   |   |   |   |   |
|------------------|-------------------|--------------------------------|---|---|---|---|---|---|---|
|                  |                   | 1                              | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 58.0             | L                 | G                              | G | G | G | G | G | G | G |
| 42.0             | R                 | R                              | R | R | R | R | R | R | R |
| 58.0             | R                 | G                              | G | G | G | G | G | G | G |
| 42.0             | L                 | R                              | R | R | R | R | R | R | R |
| 57.0             | L                 | G                              | G | G | G | G | G | G | G |
| 43.0             | R                 | R                              | R | R | R | R | R | R | R |
| 57.0             | R                 | G                              | G | G | G | G | G | G | G |
| 43.0             | L                 | R                              | R | R | R | R | R | R | R |
| 56.0             | L                 | G                              | G | G | G | G | G | G | G |
| 44.0             | R                 | R                              | R | R | R | R | R | R | R |
| 56.0             | R                 | G                              | G | G | G | G | G | G | G |
| 44.0             | L                 | R                              | R | R | R | R | R | R | R |
| 55.0             | R                 | G                              | G | G | G | G | G | G | G |
| 45.0             | L                 | R                              | R | R | R | R | R | R | R |
| 55.0             | L                 | G                              | G | G | G | G | G | G | G |
| 45.0             | R                 | R                              | R | R | R | R | R | R | R |
| 54.0             | L                 | G                              | G | G | G | G | G | G | G |
| 46.0             | R                 | R                              | R | R | R | R | R | R | R |
| 54.0             | R                 | G                              | G | G | G | G | G | G | G |
| 46.0             | L                 | R                              | G | R | R | R | R | R | R |
| 53.0             | L                 | G                              | G | G | G | G | G | G | G |
| 47.0             | R                 | G                              | R | R | R | G | R | R | R |
| 53.0             | R                 | G                              | G | G | G | G | G | G | G |
| 47.0             | L                 | R                              | G | R | R | R | R | R | G |
| 52.0             | R                 | G                              | G | G | G | G | G | G | G |
| 48.0             | L                 | G                              | G | R | R | R | R | R | G |
| 52.0             | L                 | G                              | G | G | G | G | G | G | G |
| 48.0             | R                 | R                              | R | R | G | G | R | R | R |
| 51.0             | R                 | G                              | G | G | G | G | G | G | G |
| 49.0             | L                 | G                              | G | G | R | G | R | G | R |
| 51.0             | L                 | G                              | G | G | G | G | G | G | G |
| 49.0             | R                 | G                              | G | G | G | G | R | R | G |
| 50.0             | L                 | G                              | G | G | G | G | G | G | G |
| 50.0             | R                 | G                              | G | R | G | G | G | G | G |

# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 2 Date: 17 April Time: 3 p.m. Day No: 11

Subject: Kathryn Serial Status of Test: 3 days after control sessions, total viewing time 5.6 hours.

Purpose: To establish nature and extent of laterality bias in system.  
Method of Single Stimuli, Dichotomous (R/G) Responses.

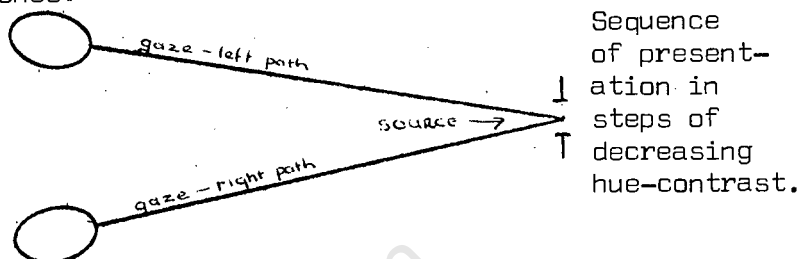
Viewing Conditions: No mirrors, oblique viewing angles, no head movements, no headphones, no tones.

Left path in one series,  
Right path in one series.

Viewing time per stimulus:

1 sec. Interval between stimuli: +10 secs. Eyes masked between presentations. Range of vernier settings: 42-58

(0 = Max. Red; 100 = Max. Blue-Green)



| Vernier Settings | Viewing                                 | O's Verbal Responses |   |   |   |   |   |   |   |
|------------------|-----------------------------------------|----------------------|---|---|---|---|---|---|---|
|                  |                                         | Sequences            |   |   |   |   |   |   |   |
|                  |                                         | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 58.0             | Gaze-forward in Oblique<br>(left) path  | G                    | G | G | G | G | G | G | G |
| 42.0             |                                         | R                    | R | R | R | R | R | R | R |
| 57.0             |                                         | G                    | G | G | G | G | G | G | G |
| 43.0             |                                         | R                    | R | R | R | R | R | R | R |
| 56.0             |                                         | G                    | G | G | G | G | G | G | G |
| 44.0             |                                         | R                    | R | R | R | R | R | R | R |
| 55.0             |                                         | G                    | G | G | G | G | G | G | G |
| 45.0             |                                         | R                    | R | R | R | R | R | R | R |
| 54.0             |                                         | G                    | G | G | G | G | G | G | G |
| 46.0             |                                         | R                    | R | R | R | G | R | G | R |
| 53.0             |                                         | G                    | G | G | G | G | G | G | G |
| 47.0             |                                         | G                    | G | G | G | G | R | G | G |
| 52.0             |                                         | G                    | G | G | G | G | G | G | G |
| 48.0             |                                         | G                    | G | G | G | G | G | G | G |
| 51.0             |                                         | G                    | G | G | G | G | G | G | G |
| 49.0             |                                         | G                    | G | G | G | G | G | G | G |
| 50.0             |                                         | G                    | G | G | G | G | G | G | G |
| 58.0             |                                         | G                    | G | G | G | G | G | G | G |
| 42.0             | Gaze-forward in Oblique<br>(right) path | R                    | R | R | R | R | R | R | R |
| 57.0             |                                         | G                    | G | G | G | G | G | G | G |
| 43.0             |                                         | R                    | R | R | R | R | R | R | R |
| 56.0             |                                         | G                    | G | G | G | G | G | G | G |
| 44.0             |                                         | R                    | R | R | R | R | R | R | R |
| 55.0             |                                         | G                    | G | G | G | G | G | G | G |
| 45.0             |                                         | R                    | R | R | R | R | R | R | R |
| 54.0             |                                         | G                    | G | G | G | G | G | G | G |
| 46.0             |                                         | R                    | G | R | G | R | R | R | R |
| 53.0             |                                         | G                    | G | G | G | G | G | G | G |
| 47.0             |                                         | R                    | R | R | R | G | G | G | R |
| 52.0             |                                         | G                    | G | G | G | G | G | G | G |
| 48.0             |                                         | G                    | G | G | G | G | G | G | G |
| 51.0             |                                         | G                    | G | G | G | G | G | G | G |
| 49.0             |                                         | G                    | G | G | G | G | G | G | G |
| 50.0             |                                         | G                    | G | G | G | G | G | G | G |

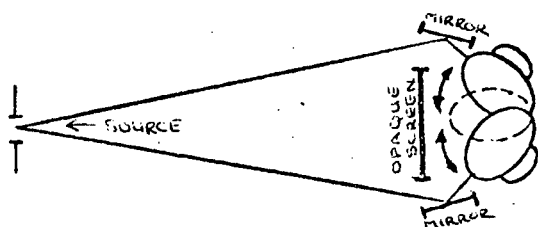
# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 3 Date: 29 April Time: 2 p.m. Day No: 23  
 Subject: Kathryn Serial Status of Test: First post-experimental  
 test, 24 hours after completion of 5.9 hours training (76 sessions,  
 5472 trials). Purpose: To establish nature and extent of gaze-  
 contingent hue-shift.

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: As for Paula, Data Sheet 4, except that Red filter  
 during training in gaze-right path  
 and Blue-Green filter during  
 training in gaze-left path.

Range of vernier settings: 42-58  
 (0 = Max. Red; 100 = Max. Blue-  
 Green)

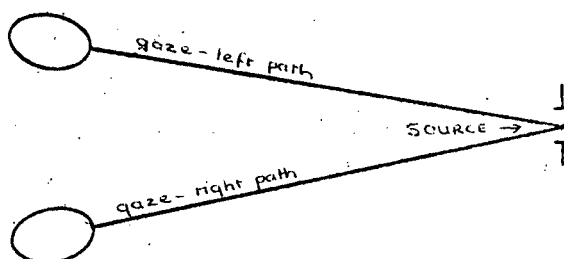


| Vernier<br>Setting | Direction<br>of<br>Gaze | O's Verbal Responses |   |   |   |   |   |   |   |
|--------------------|-------------------------|----------------------|---|---|---|---|---|---|---|
|                    |                         | Sequences            |   |   |   |   |   |   |   |
|                    |                         | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 56.0               | L                       | G                    | G | G | G | G | G | G | G |
| 40.0               | R                       | R                    | R | R | R | R | R | R | R |
| 56.0               | R                       | G                    | G | G | G | G | G | G | G |
| 40.0               | L                       | R                    | R | R | R | R | R | R | R |
| 55.0               | L                       | G                    | G | G | G | G | G | G | G |
| 41.0               | R                       | R                    | R | R | R | R | R | R | R |
| 55.0               | R                       | G                    | G | G | G | G | G | G | G |
| 41.0               | L                       | R                    | R | R | R | R | R | R | R |
| 54.0               | L                       | G                    | G | G | G | G | G | G | G |
| 42.0               | R                       | R                    | R | R | R | R | R | R | R |
| 54.0               | R                       | G                    | G | G | G | G | G | G | G |
| 42.0               | L                       | R                    | R | R | R | R | R | R | R |
| 53.0               | R                       | G                    | G | G | G | G | G | G | G |
| 43.0               | L                       | R                    | R | R | R | R | R | R | R |
| 53.0               | L                       | G                    | G | G | G | G | G | G | G |
| 43.0               | R                       | R                    | R | R | R | R | R | R | R |
| 52.0               | L                       | G                    | G | G | G | G | G | G | G |
| 44.0               | R                       | R                    | R | R | G | R | R | R | R |
| 52.0               | R                       | G                    | G | G | G | G | G | G | G |
| 44.0               | L                       | R                    | R | R | R | R | R | R | R |
| 51.0               | L                       | G                    | G | G | G | G | G | G | G |
| 45.0               | R                       | R                    | R | R | G | R | R | R | R |
| 51.0               | R                       | G                    | G | G | G | G | G | G | G |
| 45.0               | L                       | R                    | R | R | R | R | R | R | R |
| 50.0               | R                       | G                    | G | G | G | G | G | G | G |
| 46.0               | L                       | R                    | R | R | R | R | R | R | R |
| 50.0               | L                       | G                    | G | G | G | G | G | G | G |
| 46.0               | R                       | R                    | R | R | R | G | R | G | R |
| 49.0               | R                       | G                    | G | G | G | G | G | G | G |
| 47.0               | L                       | R                    | R | R | G | R | G | R | G |
| 49.0               | L                       | R                    | R | R | G | R | G | G | G |
| 47.0               | R                       | G                    | R | G | R | G | G | G | G |
| 48.0               | L                       | R                    | R | R | R | R | G | G | R |
| 48.0               | R                       | R                    | G | R | G | G | G | G | G |

# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 4 Date: 29 April Time: 3 p.m. Day No: 23  
 Subject: Kathryn Serial Status of Test: After completion of first experimental phase. Purpose: To establish nature and extent of laterality bias in system.  
 Method of Single Stimuli, Dichotomous (R/G) Responses  
 Viewing Conditions: See Kathryn Data Sheet 2.

Range of Settings:  
 40-56  
 (0 = Max. Red;  
 100 = Max. Blue-Green)

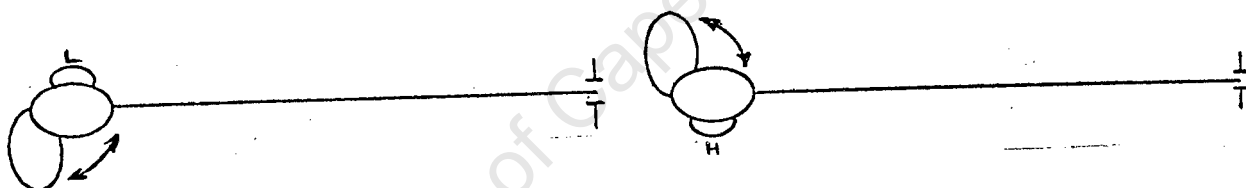


| Vernier Settings | Viewing                              | O's Verbal Responses |   |   |   |   |   |   |   |
|------------------|--------------------------------------|----------------------|---|---|---|---|---|---|---|
|                  |                                      | Sequences            |   |   |   |   |   |   |   |
|                  |                                      | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 56.0             | Gaze-forward in (oblique) left path  | G                    | G | G | G | G | G | G | G |
| 40.0             |                                      | R                    | R | R | R | R | R | R | R |
| 55.0             |                                      | G                    | G | G | G | G | G | G | G |
| 41.0             |                                      | R                    | R | R | R | R | R | R | R |
| 54.0             |                                      | G                    | G | G | G | G | G | G | G |
| 42.0             |                                      | R                    | R | R | R | R | R | R | R |
| 53.0             |                                      | G                    | G | G | G | G | G | G | G |
| 43.0             |                                      | R                    | R | R | R | R | R | R | R |
| 52.0             |                                      | G                    | G | G | G | G | G | G | G |
| 44.0             |                                      | R                    | R | R | R | R | R | R | R |
| 51.0             |                                      | G                    | G | G | G | G | G | G | G |
| 45.0             |                                      | R                    | R | R | R | R | R | G | R |
| 50.0             |                                      | G                    | G | G | G | G | G | G | G |
| 46.0             |                                      | R                    | R | R | R | R | G | R | R |
| 49.0             |                                      | G                    | G | G | G | G | G | G | G |
| 47.0             |                                      | G                    | G | G | G | R | G | R | G |
| 48.0             |                                      | G                    | G | G | G | G | G | G | G |
| 56.0             | Gaze-forward in (oblique) right path | G                    | G | G | G | G | G | G | G |
| 40.0             |                                      | R                    | R | R | R | R | R | R | R |
| 55.0             |                                      | G                    | G | G | G | G | G | G | G |
| 41.0             |                                      | R                    | R | R | R | R | R | R | R |
| 54.0             |                                      | G                    | G | G | G | G | G | G | G |
| 42.0             |                                      | R                    | R | R | R | R | R | R | R |
| 53.0             |                                      | G                    | G | G | G | G | G | G | G |
| 43.0             |                                      | R                    | R | R | R | R | R | R | R |
| 52.0             |                                      | G                    | G | G | G | G | G | G | G |
| 44.0             |                                      | R                    | R | R | R | R | R | R | R |
| 51.0             |                                      | G                    | G | G | G | G | G | G | G |
| 45.0             |                                      | R                    | R | R | R | G | G | R | R |
| 50.0             |                                      | G                    | G | G | G | G | G | G | G |
| 46.0             |                                      | R                    | R | R | G | G | G | R | R |
| 49.0             |                                      | G                    | G | G | G | G | G | G | R |
| 47.0             |                                      | R                    | R | G | R | G | G | G | G |
| 48.0             |                                      | G                    | G | G | G | G | G | G | G |



# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 5 Date: 24 May Time: 2 p.m. Day No: 48  
 Subject: Kathryn Serial Status of Test: Beginning of final post-experimental testing programme: 24 hours after last experimental session, total of 18 days of training sessions, av. 40 mins. per day over 36 days, total 11.8 hours (192 sessions, 13,824 trials).  
 Purpose: To establish nature and extent of gaze-contingent hue shift.  
 Method of Adjustment for Subjective Neutral Point  
 Viewing Conditions: No mirrors. Viewing angle perpendicular to colour-mixer. Gaze-left only in one series, followed by gaze-right only in one series. Stimuli switched on by O's head-movements.  
 N.B. Viewing time under computer-control: interrupted every 4 seconds. Interval between vernier adjustment periods: 4 seconds. Computer programmed to signal, via relevant tone, when O should turn head and continue making adjustment.  
 Headphones worn. Low tone (260 Hz) in left ear, gaze-left. High tone (390 Hz) in right ear, gaze-right. Red filter during training in gaze-right position. Blue-Green filter during training in gaze-left position.



| Viewing: Left |                              |                 | Viewing: Right               |                 |
|---------------|------------------------------|-----------------|------------------------------|-----------------|
| Trial No.     | Initial Colour-Mixer Setting | Vernier Reading | Initial Colour-Mixer Setting | Vernier Reading |
| 1             | G                            | 47.3            | G                            | 45.4            |
| 2             | R                            | 45.8            | R                            | 45.0            |
| 3             | G                            | 46.1            | G                            | 44.9            |
| 4             | R                            | 47.3            | R                            | 42.9            |
| 5             | G                            | 46.7            | G                            | 43.0            |
| 6             | R                            | 45.7            | R                            | 43.0            |
| 7             | G                            | 47.5            | G                            | 42.3            |
| 8             | R                            | 47.0            | R                            | 42.8            |
| 9             | G                            | 47.5            | G                            | 44.2            |
| 10            | R                            | 45.0            | R                            | 43.1            |
| 11            | G                            | 44.2            | G                            | 44.3            |
| 12            | R                            | 44.1            | R                            | 42.8            |
| 13            | G                            | 45.0            | G                            | 42.9            |
| 14            | R                            | 44.9            | R                            | 41.9            |
| 15            | G                            | 45.0            | G                            | 41.0            |
| 16            | R                            | 45.2            | R                            | 41.8            |
| 17            | G                            | 46.3            | G                            | 40.8            |
| 18            | R                            | 44.1            | R                            | 41.0            |
| 19            | G                            | 47.7            | G                            | 40.4            |
| 20            | R                            | 43.4            | R                            | 38.0            |

# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 6 Date: 24 May Time: 3 p.m. Day No: 48  
 Subject: Kathryn Serial Status of Test: Final post-experimental testing programme 24 hours after last experimental session.  
 Purpose: To establish O's neutral point, without head-turning or tones or mirrors.

Method of Adjustment, Computer Controlled,

Viewing Conditions: No mirrors. Viewing angle perpendicular to colour-mixer. No head-movements. Gaze-forward only. Intermittent viewing and adjusting, 4 seconds on, 4 seconds off; under computer control, tone to E serving as E's signal to O to open eyes. Vernier Scale: 0 = Max. Red; 100 = Max. Blue-Green. (Mixer adjusted by E to about 10 scale units (alternately towards G and R) beyond O's neutral setting, in successive trials).



Viewing: Forward

| Trial No. | Initial Colour-Mixer Setting | Vernier Reading |
|-----------|------------------------------|-----------------|
| 1         | G                            | 44.9            |
| 2         | R                            | 41.0            |
| 3         | G                            | 44.9            |
| 4         | R                            | 41.1            |
| 5         | G                            | 42.6            |
| 6         | R                            | 42.4            |
| 7         | G                            | 42.6            |
| 8         | R                            | 39.4            |
| 9         | G                            | 41.4            |
| 10        | R                            | 41.1            |
| 11        | G                            | 41.4            |
| 12        | R                            | 39.6            |
| 13        | G                            | 40.3            |
| 14        | R                            | 42.4            |
| 15        | G                            | 41.0            |
| 16        | R                            | 40.5            |
| 17        | G                            | 43.6            |
| 18        | R                            | 39.4            |
| 19        | G                            | 45.0            |
| 20        | R                            | 40.0            |

CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

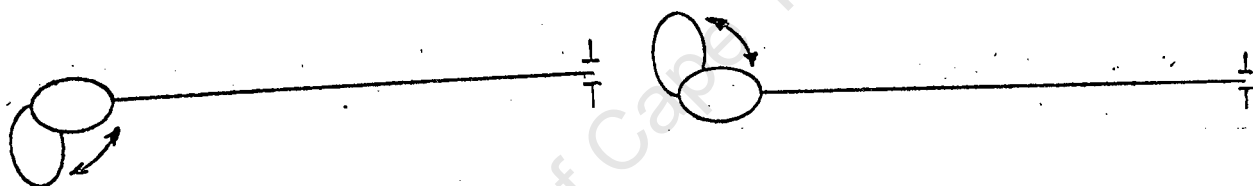
Data Sheet: 7 Date: 25 May Time: 2 p.m. Day No: 49

Subject: Kathryn Serial Status of Test: Final post-experimental testing programme 48 hours after last experimental session.

Purpose: To establish nature and extent of gaze-contingent hue-shift without tones in ears.

Method of Adjustment, for Subjective Neutral Point

Viewing Conditions: No mirrors. Viewing angle perpendicular to colour-mixer. Gaze-left only in one series followed by gaze-right only in one series. No headphones. No tones. Viewing time under computer control, 4 seconds. Tone to E served as E's signal to Q to turn head in appropriate direction. Interval between vernier adjustment periods: 4 seconds. Vernier Scale: 0 = Max. Red; 100 = Max. Blue-Green. (Mixer adjusted by E to about 10 scale units (alternately towards G and R) beyond Q's neutral setting, in successive trials).



| Trial No. | Gaze-Left                    |                 | Gaze-Right                   |                 |
|-----------|------------------------------|-----------------|------------------------------|-----------------|
|           | Initial Colour-Mixer Setting | Vernier Reading | Initial Colour-Mixer Setting | Vernier Reading |
| 1         | G                            | 44.4            | G                            | 45.5            |
| 2         | R                            | 43.0            | R                            | 44.4            |
| 3         | G                            | 44.3            | G                            | 44.5            |
| 4         | R                            | 44.5            | R                            | 43.8            |
| 5         | G                            | 44.9            | G                            | 45.0            |
| 6         | R                            | 43.1            | R                            | 42.0            |
| 7         | G                            | 44.9            | G                            | 44.4            |
| 8         | R                            | 43.9            | R                            | 45.0            |
| 9         | G                            | 43.4            | G                            | 45.1            |
| 10        | R                            | 43.9            | R                            | 44.4            |
| 11        | G                            | 42.9            | G                            | 45.0            |
| 12        | R                            | 43.3            | R                            | 42.8            |
| 13        | G                            | 45.1            | G                            | 45.5            |
| 14        | R                            | 42.8            | R                            | 44.1            |
| 15        | G                            | 43.7            | G                            | 45.5            |
| 16        | R                            | 43.5            | R                            | 44.5            |
| 17        | G                            | 42.6            | G                            | 45.6            |
| 18        | R                            | 44.0            | R                            | 44.4            |
| 19        | G                            | 43.0            | G                            | 47.2            |
| 20        | R                            | 42.2            | R                            | 45.6            |

CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

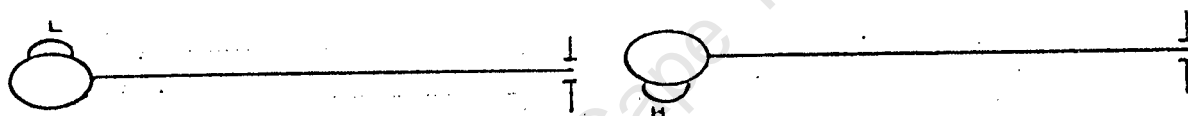
Data Sheet: 8 Date: 25 May Time: 3 p.m. Day No: 49

Subject: Kathryn Serial Status of Test: Final post-experimental testing programme 48 hours after last experimental session.

Purpose: To establish nature and extent of tone-contingent hue-shift without head-movements.

Method of Adjustment for Subjective Neutral Point

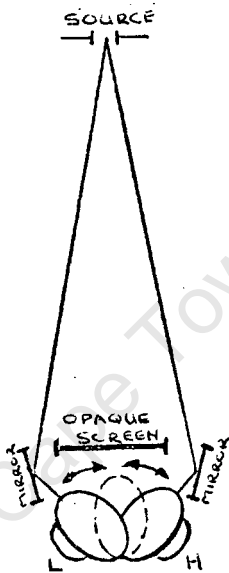
Viewing Conditions: No mirrors. Viewing angle perpendicular to colour-mixer. No head-movements. Headphones worn, Low tone (260 Hz) in left ear, High tone (390 Hz) in right ear. Viewing time under computer control, 4 seconds on, 4 seconds off, tone serving as signal to Q to open eyes. Low tone only in one series, followed by high tone only in one series. Mixer adjusted by E to about 10 scale units (alternately towards G and R) beyond Q's neutral setting, in successive trials. (Vernier Scale: 0 = Max. Red; 100 = Max. Blue-Green)



| Low Tone in Left Ear |                              |                 | High Tone in Right Ear       |                 |
|----------------------|------------------------------|-----------------|------------------------------|-----------------|
| Viewing: Forward     |                              |                 | Viewing: Forward             |                 |
| Trial No.            | Initial Colour-Mixer Setting | Vernier Reading | Initial Colour-Mixer Setting | Vernier Reading |
| 1                    | G                            | 43.8            | G                            | 45.0            |
| 2                    | R                            | 45.5            | R                            | 45.1            |
| 3                    | G                            | 42.9            | G                            | 45.9            |
| 4                    | R                            | 43.5            | R                            | 46.2            |
| 5                    | G                            | 44.4            | G                            | 45.5            |
| 6                    | R                            | 42.6            | R                            | 45.0            |
| 7                    | G                            | 43.3            | G                            | 45.6            |
| 8                    | R                            | 43.5            | R                            | 44.2            |
| 9                    | G                            | 44.0            | G                            | 45.1            |
| 10                   | R                            | 43.9            | R                            | 43.9            |
| 11                   | G                            | 45.5            | G                            | 46.3            |
| 12                   | R                            | 42.8            | R                            | 44.5            |
| 13                   | G                            | 44.5            | G                            | 45.6            |
| 14                   | R                            | 43.8            | R                            | 44.9            |
| 15                   | G                            | 45.1            | G                            | 44.0            |
| 16                   | R                            | 43.6            | R                            | 44.1            |
| 17                   | G                            | 45.2            | G                            | 44.0            |
| 18                   | R                            | 44.5            | R                            | 44.2            |
| 19                   | G                            | 45.8            | G                            | 45.0            |
| 20                   | R                            | 43.4            | R                            | 45.0            |

CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 9    Date: 26 May    Time: 2 p.m.    Day No: 50  
Subject: Kathryn    Serial Status of Test: Final post-experimental testing programme 72 hours after last experimental session.  
Purpose: To determine nature and extent of gaze-and-tone-contingent hue-shift. Method of Adjustment for Subjective Neutral Point.  
Viewing Conditions: Oblique viewing angles Via Mirrors(M). Head-phones worn, Low tone (260 Hz) in left ear gaze-left; High tone (390 Hz) in right ear, gaze-right. Gaze left only in one series followed by gaze-right only in one series. Viewing time under computer control, 4 seconds on, 4 seconds off; tone serving as signal to Q to move head in appropriate direction.



Two-colour mixer  
2° circular field  
Luminance: See p. 246 a.  
Mixer adjusted by E to about 10 scale units (alternately towards G and R) beyond Q's neutral setting in successive trials.  
Vernier Scale:  
0 = Max. Red;  
100 = Max. Blue-Green

| Viewing: Left |                              |                 | Viewing: Right               |                 |  |
|---------------|------------------------------|-----------------|------------------------------|-----------------|--|
| Trial No.     | Initial Colour-Mixer Setting | Vernier Reading | Initial Colour-Mixer Setting | Vernier Reading |  |
| 1             | G                            | 47.5            | G                            | 45.8            |  |
| 2             | R                            | 47.4            | R                            | 45.3            |  |
| 3             | G                            | 47.3            | G                            | 46.5            |  |
| 4             | R                            | 46.2            | R                            | 43.6            |  |
| 5             | G                            | 48.2            | G                            | 44.2            |  |
| 6             | R                            | 46.6            | R                            | 43.3            |  |
| 7             | G                            | 46.4            | G                            | 44.4            |  |
| 8             | R                            | 45.6            | R                            | 43.6            |  |
| 9             | G                            | 47.6            | G                            | 45.0            |  |
| 10            | R                            | 45.4            | R                            | 44.0            |  |
| 11            | G                            | 46.0            | G                            | 45.2            |  |
| 12            | R                            | 46.4            | R                            | 44.5            |  |
| 13            | G                            | 46.7            | G                            | 44.2            |  |
| 14            | R                            | 46.3            | R                            | 44.2            |  |
| 15            | G                            | 46.4            | G                            | 43.5            |  |
| 16            | R                            | 46.2            | R                            | 42.6            |  |
| 17            | G                            | 47.4            | G                            | 44.2            |  |
| 18            | R                            | 45.5            | R                            | 44.3            |  |
| 19            | G                            | 47.6            | G                            | 44.1            |  |
| 20            | R                            | 47.5            | R                            | 43.3            |  |

# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

Data Sheet: 10 Date: 26 May Time: 3 p.m. Day No: 50

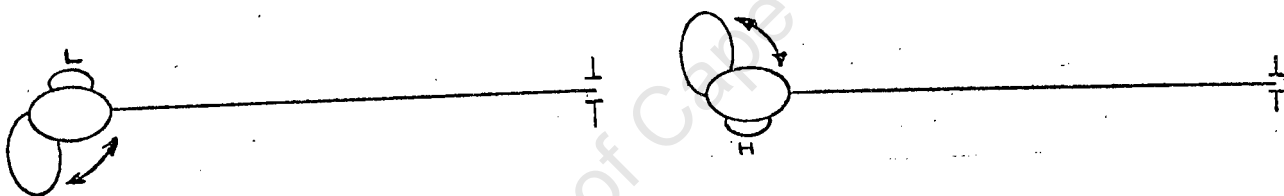
Subject: Kathryn Serial Status of Test: Final post-experimental testing programme, 72 hours after last experimental session.

Purpose: To determine nature and extent of gaze-and-tone-contingent hue shift

Method of Adjustment for Subjective Neutral Point

Viewing Conditions: No mirrors. Viewing angle perpendicular to colour-mixer. Headphones worn. Low tone (260 Hz) in left ear, gaze-left; High tone (390 Hz) in right ear, gaze-right. Gaze-left only in one series, followed by gaze-right only in one series. Viewing time under computer control, tone serving as signal to O to move head in appropriate direction. Duration of stimuli while adjustment is being made, 4 seconds. Duration of interval between successive manipulations of vernier knob, 4 seconds.

Mixer adjusted by E to about 10 scale units (alternately towards R and G) beyond O's neutral setting, in successive trials. (Vernier Scale: 0 = Max. Red; 100 = Max. Blue-Green)



| Trial No. | Gaze-Left                    |                 | Gaze-Right                   |                 |
|-----------|------------------------------|-----------------|------------------------------|-----------------|
|           | Initial Colour-Mixer Setting | Vernier Reading | Initial Colour-Mixer Setting | Vernier Reading |
| 1         | G                            | 45.8            | G                            | 45.5            |
| 2         | R                            | 45.4            | R                            | 44.5            |
| 3         | G                            | 44.3            | G                            | 44.2            |
| 4         | R                            | 43.9            | R                            | 43.3            |
| 5         | G                            | 45.0            | G                            | 44.5            |
| 6         | R                            | 43.2            | R                            | 43.3            |
| 7         | G                            | 45.0            | G                            | 44.5            |
| 8         | R                            | 43.6            | R                            | 43.7            |
| 9         | G                            | 45.7            | G                            | 45.5            |
| 10        | R                            | 44.4            | R                            | 43.8            |
| 11        | G                            | 45.0            | G                            | 45.8            |
| 12        | R                            | 45.5            | R                            | 42.7            |
| 13        | G                            | 44.1            | G                            | 42.8            |
| 14        | R                            | 44.0            | R                            | 41.8            |
| 15        | G                            | 45.9            | G                            | 41.5            |
| 16        | R                            | 44.6            | R                            | 42.7            |
| 17        | G                            | 44.2            | G                            | 41.5            |
| 18        | R                            | 43.8            | R                            | 42.4            |
| 19        | G                            | 45.5            | G                            | 42.8            |
| 20        | R                            | 44.9            | R                            | 43.9            |

# CONDITIONING OF GAZE-CONTINGENT HUE-RESPONSES: TESTING SESSION(S)

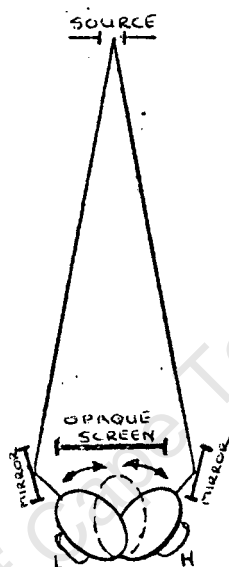
Data Sheet: 11 Date: 29 May Time: 2 p.m. Day No: 53

Subject: Kathryn Serial Status of Test: Final post-experimental testing programme, 6 days after last experimental session.

Purpose: To determine nature and extent of gaze-and-tone-contingent hue-shift. Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: Oblique viewing angles Via Mirrors(M)

Head movements, random alternations of left and right. Viewing time per stimulus: +1 sec. Interval between stimuli: 10+10 secs. Red filter during training in gaze-right path; Blue-Green filter during training in gaze-left path. Headphones worn, Low tone (260 Hz) in left ear on gaze-left; High tone (390 Hz) in right ear on gaze-right.



Two-colour mixer

2° circular field

Luminance: See p. 246a.

Settings via vernier dial  
Range 43-50

Sequence of presentation:  
In steps of decreasing  
hue-contrast.

(0 = Max. Red; 100 = Max.  
Blue-Green)

| Vernier<br>Settings | Viewing | O's Verbal Responses<br>Sequences |   |   |   |   |   |   |   |
|---------------------|---------|-----------------------------------|---|---|---|---|---|---|---|
|                     |         | 1                                 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 50.0                | L       | G                                 | G | G | G | G | G | G | G |
| 43.0                | L       | R                                 | R | R | R | R | R | R | R |
| 50.0                | R       | G                                 | G | G | G | G | G | G | G |
| 43.0                | R       | R                                 | R | R | R | R | R | R | R |
| 49.0                | L       | G                                 | G | G | G | G | G | G | G |
| 44.0                | R       | R                                 | R | R | R | R | R | R | R |
| 49.0                | R       | G                                 | G | G | G | G | G | G | G |
| 44.0                | L       | R                                 | R | R | R | R | R | R | R |
| 48.0                | L       | G                                 | G | R | G | G | R | G | G |
| 45.0                | L       | R                                 | R | R | R | R | R | R | R |
| 48.0                | R       | R                                 | G | R | R | G | R | R | R |
| 45.0                | R       | R                                 | R | R | R | R | R | R | R |
| 47.0                | R       | G                                 | G | G | R | G | R | G | G |
| 46.0                | R       | R                                 | R | R | R | R | R | R | R |
| 47.0                | L       | G                                 | R | G | G | R | G | G | G |
| 46.0                | L       | R                                 | R | G | R | G | R | R | R |

DATE: 16 MAY

SUBJECT: KW EX 131 E 23

| BLOCN | NFEED | SESSN | IWAIT | SINGL |
|-------|-------|-------|-------|-------|
| 72    | 72    | 72    | 0     | 0     |

| TIMEP | TIMEI | TIMEF | TIMES |
|-------|-------|-------|-------|
| 50    | 1     | 50    | 500   |

STARTING TRIAL NO: 8388

PAUSE

8459 90.3 301. 110. 634. 203.

|       |    |   |      |      |            |             |          |
|-------|----|---|------|------|------------|-------------|----------|
| 1 - 0 | 5  | 0 | 288. | 61.  | EEEEEEEEEE | .EEEEEEEEEE | .        |
| 1 - 2 | 4  | 1 | 289. | 66.  | 262.       | . 994.      | .        |
| 1 - 4 | 4  | 1 | 266. | 59.  | 278.       | . 397.      | .        |
| 2 - 0 | 5  | 0 | 238. | 29.  | EEEEEEEEEE | .EEEEEEEEEE | .        |
| 2 - 2 | 6  | 1 | 424. | 161. | 271.       | . 597.      | .        |
| 2 - 4 | 5  | 0 | 362. | 184. | EEEEEEEEEE | .EEEEEEEEEE | .        |
| 3 - 3 | 4  | 1 | 309. | 68.  | 270.       | . 705.      | .        |
| 3 - 5 | 6  | 1 | 338. | 97.  | 311.       | . 751.      | .        |
| 3 - 7 | 4  | 0 | 325. | 88.  | EEEEEEEEEE | .EEEEEEEEEE | .        |
| 0 - 0 | 29 | 2 | 262. | 66.  | 545.       | 334.        | 498. 66. |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: COMPUTER PRINTOUT OF  
EXPERIMENTAL SESSION



## Appendix 14.

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA  
 (Culled from computer printout)

Subject: Paula

| DATE    | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX:<br>MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES |
|---------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|----------------------------------------------|---------------------|
| 2 March | 1       | 1           | 72                      | S                  | 8                     | 8                        | 16           | 7.91                         | 11.15                                   | 748                          | 127                                          | 2.76 hours          |
|         |         | 2           | 144                     |                    | 6                     | 5                        | 11           | 7.24                         | 12.22                                   | 655                          | 80                                           |                     |
|         |         | 3           | 216                     |                    | 3                     | 4                        | 7            | 7.01                         | 7.25                                    | 556                          | 49                                           |                     |
|         |         | 4           | 288                     |                    | 4                     | 7                        | 11           | 5.36                         | 7.49                                    | 468                          | 59                                           |                     |
|         |         | 5           | 360                     |                    | 5                     | 3                        | 8            | 6.97                         | 8.74                                    | 572                          | 56                                           |                     |
|         |         | 6           | 432                     |                    | 5                     | 9                        | 14           | 6.10                         | 8.72                                    | 561                          | 85                                           |                     |
|         |         | 7           | 504                     |                    | 7                     | 9                        | 16           | 5.40                         | 8.22                                    | 521                          | 87                                           |                     |
|         |         | 8           | 576                     |                    | 5                     | 6                        | 11           | 5.35                         | 5.95                                    | 450                          | 59                                           |                     |
|         |         | 9           | 648                     |                    | 4                     | 7                        | 11           | 6.01                         | 9.39                                    | 536                          | 66                                           |                     |
|         |         | 10          | 720                     |                    | 3                     | 5                        | 8            | 5.91                         | 6.59                                    | 479                          | 47                                           |                     |
|         |         | 11          | 792                     |                    | 2                     | 7                        | 9            | 4.90                         | 9.84                                    | 442                          | 44                                           |                     |
|         |         | 12          | 864                     |                    | 5                     | 4                        | 9            | 5.13                         | 4.58                                    | 410                          | 46                                           |                     |
|         |         | 13          | 936                     |                    | 2                     | 7                        | 9            | 6.02                         | 4.11                                    | 470                          | 54                                           |                     |
|         |         | 14          | 1008                    |                    | 4                     | 7                        | 11           | 5.49                         | 6.06                                    | 462                          | 60                                           |                     |
|         |         | 15          | 1080                    |                    | 2                     | 5                        | 7            | 4.10                         | 6.34                                    | 339                          | 29                                           |                     |
|         |         | 16          | 1152                    |                    | 3                     | 6                        | 9            | 3.78                         | 5.44                                    | 321                          | 34                                           |                     |
|         |         | 17          | 1224                    |                    | 1                     | 5                        | 6            | 4.44                         | 5.11                                    | 351                          | 27                                           |                     |
|         |         | 18          | 1296                    |                    | 2                     | 5                        | 7            | 4.50                         | 4.74                                    | 357                          | 32                                           |                     |
|         |         | 19          | 1368                    |                    | 3                     | 5                        | 8            | 3.45                         | 5.56                                    | 292                          | 28                                           |                     |
|         |         | 20          | 1440                    |                    | 2                     | 6                        | 8            | 3.89                         | 5.70                                    | 326                          | 31                                           |                     |
|         |         | 21          | 1512                    |                    | 0                     | 4                        | 4            | 3.89                         | 4.59                                    | 298                          | 16                                           |                     |
|         |         | 22          | 1584                    |                    | 2                     | 6                        | 8            | 4.21                         | 4.49                                    | 339                          | 34                                           |                     |
| 3 March | 2       | 23          | 1656                    | S                  | 0                     | 1                        | 1            | 4.73                         | 10.64                                   | 352                          | 4.7                                          |                     |
|         |         | 24          | 1728                    |                    | 0                     | 5                        | 5            | 3.69                         | 6.15                                    | 297                          | 19                                           |                     |
|         |         | 25          | 1800                    |                    | 2                     | 0                        | 2            | 3.59                         | 16.36                                   | 291                          | 7.1                                          |                     |
|         |         | 26          | 1872                    |                    | 1                     | 3                        | 4            | 3.16                         | 5.61                                    | 250                          | 13                                           |                     |
|         |         | 27          | 1944                    |                    | 2                     | 6                        | 8            | 3.40                         | 7.45                                    | 305                          | 27                                           |                     |
|         |         | 28          | 2016                    |                    | 0                     | 2                        | 2            | 3.06                         | 6.62                                    | 233                          | 6.1                                          |                     |
|         |         | 29          | 2088                    |                    | 1                     | 4                        | 5            | 3.09                         | 6.28                                    | 253                          | 16                                           |                     |
|         |         | 30          | 2160                    |                    | 0                     | 3                        | 3            | 3.00                         | 6.62                                    | 236                          | 9.0                                          |                     |
|         |         | 31          | 2232                    |                    | 2                     | 4                        | 6            | 3.00                         | 4.77                                    | 245                          | 18                                           |                     |
|         |         | 32          | 2304                    |                    | 2                     | 9                        | 11           | 2.99                         | 4.52                                    | 265                          | 33                                           |                     |
|         |         | 33          | 2376                    |                    | 1                     | 4                        | 5            | 2.79                         | 4.23                                    | 222                          | 14                                           |                     |
|         |         | 34          | 2448                    |                    | 2                     | 5                        | 7            | 2.68                         | 4.92                                    | 226                          | 19                                           |                     |
|         |         | 35          | 2520                    |                    | 0                     | 3                        | 3            | 2.73                         | 5.96                                    | 315                          | 8.2                                          |                     |
|         |         | 36          | 2592                    |                    | 0                     | 5                        | 5            | 2.77                         | 5.02                                    | 224                          | 14                                           |                     |
|         |         | 37          | 2664                    |                    | 1                     | 4                        | 5            | 2.73                         | 5.04                                    | 222                          | 14                                           |                     |
|         |         | 38          | 2736                    |                    | 2                     | 5                        | 7            | 3.29                         | 3.60                                    | 262                          | 23                                           |                     |

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Paula (cont)

| DATE    | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX:<br>MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES    |
|---------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|----------------------------------------------|------------------------|
| 3 March | 2       | 39          | 2808                    | S                  | 3                     | 4                        | 7            | 3.01                         | 5.13                                    | 253                          | 21                                           | 2.02 hours             |
|         |         | 40          | 2880                    |                    | 0                     | 5                        | 5            | 3.04                         | 4.71                                    | 242                          | 15                                           |                        |
|         |         | 41          | 2952                    |                    | 0                     | 4                        | 4            | 3.21                         | 5.52                                    | 253                          | 13                                           |                        |
|         |         | 42          | 3024                    |                    | 3                     | 2                        | 5            | 3.02                         | 6.43                                    | 249                          | 15                                           |                        |
|         |         | 43          | 3096                    |                    | 0                     | 5                        | 5            | 2.86                         | 4.44                                    | 229                          | 14                                           |                        |
|         |         | 44          | 3168                    |                    | 1                     | 4                        | 5            | 2.89                         | 3.52                                    | 226                          | 15                                           |                        |
|         |         | 45          | 3240                    |                    | 1                     | 5                        | 6            | 3.10                         | 6.45                                    | 263                          | 19                                           |                        |
|         |         | 46          | 3312                    |                    | 2                     | 6                        | 8            | 2.70                         | 4.96                                    | 234                          | 22                                           |                        |
|         |         | 47          | 3384                    |                    | 3                     | 4                        | 7            | 3.09                         | 3.09                                    | 4.07                         | 22                                           |                        |
|         |         | 48          | 3456                    |                    | 1                     | 3                        | 4            | 2.93                         | 4.50                                    | 229                          | 11                                           |                        |
|         |         | 49          | 3528                    |                    | 1                     | 3                        | 4            | 2.75                         | 3.02                                    | 210                          | 11                                           |                        |
|         |         | 50          | 3600                    |                    | 0                     | 5                        | 5            | 2.73                         | 2.91                                    | 212                          | 14                                           |                        |
|         |         | 51          | 3672                    |                    | 1                     | 4                        | 5            | 2.96                         | 3.56                                    | 231                          | 15                                           |                        |
| 4 March | 3       | 52          | 3744                    | S                  | 0                     | 4                        | 4            | 2.89                         | 3.40                                    | 221                          | 12                                           |                        |
|         |         | 53          | 3816                    |                    | 0                     | 3                        | 3            | 2.90                         | 5.21                                    | 225                          | 8.7                                          |                        |
|         |         | 54          | 3888                    |                    | 0                     | 1                        | 1            | 2.79                         | 10.57                                   | 212                          | 2.8                                          |                        |
|         |         | 55          | 3960                    |                    | 1                     | 2                        | 3            | 3.03                         | 5.45                                    | 234                          | 9.1                                          |                        |
|         |         | 56          | 4032                    |                    | 0                     | 1                        | 1            | 2.97                         | 3.55                                    | 218                          | 3.0                                          |                        |
|         |         | 57          | 4104                    |                    | 0                     | 1                        | 1            | 2.96                         | 9.91                                    | 223                          | 3.0                                          |                        |
|         |         | 58          | 4176                    |                    | 2                     | 3                        | 5            | 3.12                         | 7.07                                    | 260                          | 16                                           |                        |
|         |         | 59          | 4248                    |                    | 0                     | 0                        | 0            | 2.61                         | -                                       | 188                          | 0                                            |                        |
|         |         | 60          | 4320                    |                    | 0                     | 3                        | 3            | 2.54                         | 6.37                                    | 202                          | 7.6                                          |                        |
|         |         | 61          | 4392                    |                    | 1                     | 2                        | 3            | 2.59                         | 6.76                                    | 206                          | 7.8                                          |                        |
|         |         | 62          | 4464                    |                    | 1                     | 2                        | 3            | 2.34                         | 5.98                                    | 186                          | 7.0                                          |                        |
|         |         | 63          | 4536                    |                    | 0                     | 3                        | 3            | 2.46                         | 7.33                                    | 198                          | 7.4                                          |                        |
|         |         | 64          | 4608                    |                    | 0                     | 2                        | 2            | 2.36                         | 4.49                                    | 180                          | 4.7                                          |                        |
|         |         | 65          | 4680                    |                    | 1                     | 3                        | 4            | 2.58                         | 7.70                                    | 224                          | 10                                           |                        |
|         |         | 66          | 4752                    |                    | 0                     | 1                        | 1            | 2.71                         | 5.95                                    | 201                          | 2.7                                          |                        |
|         |         | 67          | 4824                    |                    | 0                     | 3                        | 3            | 2.48                         | 4.78                                    | 293                          | 7.4                                          | Criterion<br>.96 hours |

# GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Paula (cont)

| DATE    | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES     |
|---------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|-------------------------|
| 6 March | 5       | 68          | 4896                    | S                  | 1                     | 3                        | 4            | 2.17                         | 5.33                                    | 177                          | 8.7                                       | Criterion<br>1.07 hours |
|         |         | 69          | 4968                    |                    | 1                     | 1                        | 2            | 2.46                         | 4.17                                    | 185                          | 4.9                                       |                         |
|         |         | 70          | 5040                    |                    | 0                     | 5                        | 5            | 2.09                         | 3.79                                    | 169                          | 10                                        |                         |
|         |         | 71          | 5112                    |                    | 2                     | 1                        | 3            | 2.30                         | 6.06                                    | 185                          | 6.9                                       |                         |
|         |         | 72          | 5184                    |                    | 2                     | 1                        | 3            | 2.52                         | 2.70                                    | 189                          | 7.6                                       |                         |
|         |         | 73          | 5256                    |                    | 0                     | 4                        | 4            | 2.43                         | 8.01                                    | 207                          | 9.7                                       |                         |
|         |         | 74          | 5328                    |                    | 2                     | 1                        | 3            | 2.45                         | 4.90                                    | 191                          | 7.4                                       |                         |
|         |         | 75          | 5400                    |                    | 1                     | 2                        | 3            | 2.34                         | 8.64                                    | 194                          | 7.0                                       |                         |
|         |         | 76          | 5472                    |                    | 1                     | 1                        | 2            | 2.14                         | 3.70                                    | 161                          | 4.3                                       |                         |
|         |         | 77          | 5544                    |                    | 1                     | 2                        | 3            | 2.45                         | 4.84                                    | 190                          | 7.4                                       |                         |
|         |         | 78          | 5616                    |                    | 1                     | 1                        | 2            | 2.25                         | 6.80                                    | 182                          | 6.8                                       |                         |
|         |         | 79          | 5688                    |                    | 0                     | 2                        | 2            | 2.14                         | 4.56                                    | 163                          | 4.3                                       |                         |
|         |         | 80          | 5760                    |                    | 1                     | 1                        | 2            | 2.10                         | 3.71                                    | 158                          | 4.2                                       |                         |
|         |         | 81          | 5832                    |                    | 1                     | 1                        | 2            | 2.29                         | 8.45                                    | 182                          | 4.6                                       |                         |
|         |         | 82          | 5904                    |                    | 0                     | 1                        | 1            | 2.44                         | 4.25                                    | 180                          | 2.4                                       |                         |
|         |         | 83          | 5975                    |                    | 0                     | 3                        | 3            | 2.14                         | 6.48                                    | 173                          | 6.4                                       |                         |
|         |         | 84          | 6047                    |                    | 1                     | 0                        | 1            | 2.00                         | 3.27                                    | 145                          | 2.0                                       |                         |
|         |         | 85          | 6119                    |                    | 1                     | 3                        | 4            | 2.19                         | 3.47                                    | 171                          | 8.8                                       |                         |
|         |         | 86          | 6191                    |                    | 0                     | 1                        | 1            | 2.15                         | 2.88                                    | 158                          | 2.2                                       |                         |
|         |         | 87          | 6263                    |                    | 0                     | 2                        | 2            | 2.19                         | 4.75                                    | 167                          | 4.4                                       |                         |
|         |         | 88          | 6335                    |                    | 2                     | 2                        | 4            | 2.17                         | 2.82                                    | 167                          | 8.7                                       |                         |
|         |         | 89          | 6407                    |                    | 0                     | 1                        | 1            | 2.15                         | 5.31                                    | 160                          | 2.2                                       |                         |
| 7 March | 6       | 90          | 6479                    | S                  | 0                     | 2                        | 2            | 2.29                         | 3.29                                    | 171                          | 4.6                                       | Criterion               |
|         |         | 91          | 6550                    |                    | 2                     | 2                        | 4            | 2.01                         | 3.03                                    | 156                          | 8.0                                       |                         |
|         |         | 92          | 6624                    |                    | 0                     | 1                        | 1            | 1.81                         | 2.88                                    | 133                          | 1.8                                       |                         |
|         |         | 93          | 6696                    |                    | 1                     | 2                        | 3            | 2.07                         | 3.98                                    | 161                          | 6.2                                       |                         |
|         |         | 94          | 6768                    |                    | 1                     | 1                        | 2            | 1.75                         | 1.25                                    | 129                          | 3.5                                       |                         |
|         |         | 95          | 6840                    |                    | 2                     | 2                        | 4            | 1.71                         | 4.89                                    | 143                          | 6.8                                       |                         |
|         |         | 96          | 6912                    |                    | 0                     | 2                        | 2            | 1.78                         | 2.99                                    | 134                          | 3.6                                       |                         |
|         |         | 97          | 6984                    |                    | 0                     | 3                        | 3            | 1.76                         | 2.83                                    | 134                          | 5.3                                       |                         |
|         |         | 98          | 7056                    |                    | 0                     | 2                        | 2            | 1.62                         | 2.03                                    | 120                          | 3.3                                       |                         |
|         |         | 99          | 7128                    |                    | 0                     | 2                        | 2            | 1.70                         | 1.31                                    | 125                          | 3.4                                       |                         |
|         |         | 100         | 7200                    |                    | 0                     | 2                        | 2            | 1.75                         | 2.41                                    | 131                          | 3.5                                       |                         |
|         |         | 101         | 7272                    |                    | 2                     | 2                        | 4            | 1.77                         | 2.98                                    | 139                          | 7.1                                       |                         |
|         |         | 102         | 7344                    |                    | 5                     | 2                        | 7            | 2.08                         | 3.28                                    | 172                          | 14.6                                      |                         |
|         |         | 103         | 7416                    |                    | 1                     | 4                        | 5            | 1.94                         | 2.62                                    | 153                          | 9.7                                       |                         |
|         |         | 104         | 7488                    |                    | 0                     | 3                        | 3            | 1.69                         | 2.68                                    | 130                          | 5.1                                       |                         |
|         |         | 105         | 7560                    |                    | 2                     | 4                        | 6            | 1.83                         | 1.78                                    | 143                          | 11                                        |                         |

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Paula (cont)

| DATE    | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES     |
|---------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|-------------------------|
| 8 March | 7       | 106         | 7632                    | S                  | 0                     | 2                        | 2            | 2.07                         | 1.39                                    | 152                          | 4.1                                       |                         |
|         |         | 107         | 7704                    |                    | 0                     | 0                        | 0            | 2.07                         | -                                       | 149                          | 0                                         | Criterion               |
|         |         | 108         | 7776                    |                    | 1                     | 0                        | 1            | 2.14                         | 3.24                                    | 157                          | 2.1                                       | Criterion               |
|         |         | 109         | 7848                    |                    | 1                     | 2                        | 3            | 2.00                         | 4.24                                    | 157                          | 6.0                                       |                         |
|         |         | 110         | 7920                    |                    | 0                     | 2                        | 2            | 2.24                         | 3.81                                    | 169                          | 4.5                                       |                         |
|         |         | 111         | 7992                    |                    | 1                     | 2                        | 3            | 2.01                         | 1.52                                    | 149                          | 6.0                                       |                         |
|         |         | 112         | 8064                    |                    | 2                     | 1                        | 3            | 1.77                         | 4.11                                    | 139                          | 5.2                                       |                         |
|         |         | 113         | 8136                    |                    | 1                     | 0                        | 1            | 1.81                         | 1.91                                    | 132                          | 1.8                                       | Criterion               |
|         |         | 114         | 8208                    |                    | 0                     | 0                        | 0            | 1.61                         | -                                       | 117                          | 0                                         | Criterion               |
|         |         | 115         | 8280                    |                    | 2                     | 1                        | 3            | 1.84                         | 3.07                                    | 141                          | 5.5                                       |                         |
|         |         | 116         | 8352                    |                    | 1                     | 2                        | 3            | 1.73                         | 2.40                                    | 132                          | 5.2                                       |                         |
|         |         | 117         | 8424                    |                    | 2                     | 1                        | 3            | 1.71                         | 1.92                                    | 129                          | 5.1                                       |                         |
|         |         | 118         | 8496                    |                    | 0                     | 2                        | 2            | 1.56                         | 1.55                                    | 115                          | 3.1                                       |                         |
|         |         | 119         | 8568                    |                    | 3                     | 0                        | 3            | 1.77                         | 1.65                                    | 132                          | 5.3                                       |                         |
|         |         | 120         | 8640                    |                    | 0                     | 2                        | 2            | 1.76                         | 1.21                                    | 129                          | 3.5                                       |                         |
|         |         | 121         | 8712                    |                    | 0                     | 2                        | 2            | 1.78                         | 3.65                                    | 135                          | 3.6                                       |                         |
|         |         | 122         | 8784                    |                    | 0                     | 3                        | 3            | 1.98                         | 4.55                                    | 157                          | 5.9                                       |                         |
|         |         | 123         | 8856                    |                    | 2                     | 1                        | 3            | 1.89                         | 2.66                                    | 144                          | 5.7                                       |                         |
|         |         | 124         | 8928                    |                    | 0                     | 1                        | 1            | 1.76                         | 1.08                                    | 138                          | 1.8                                       | Criterion               |
|         |         | 125         | 9000                    |                    | 1                     | 2                        | 3            | 1.80                         | 1.80                                    | 135                          | 5.4                                       |                         |
|         |         | 126         | 9072                    |                    | 1                     | 3                        | 4            | 1.67                         | 2.31                                    | 129                          | 6.7                                       |                         |
|         |         | 127         | 9144                    |                    | 1                     | 1                        | 2            | 1.93                         | 2.30                                    | 143                          | 3.9                                       |                         |
|         |         | 128         | 9216                    |                    | 1                     | 3                        | 4            | 1.82                         | 3.53                                    | 145                          | 7.3                                       |                         |
| 9 March | 8       | 129         | 9288                    |                    | 0                     | 2                        | 2            | 1.81                         | 2.88                                    | 136                          | 3.6                                       |                         |
|         |         | 130         | 9360                    |                    | 0                     | 2                        | 2            | 1.99                         | 3.41                                    | 150                          | 4.0                                       |                         |
|         |         | 131         | 9432                    |                    | 0                     | 0                        | 0            | 1.93                         | -                                       | 139                          | 0                                         | Criterion<br>1.01 hours |
|         |         | 132         | 9504                    | S                  | 0                     | 1                        | 1            | 1.67                         | 2.80                                    | 123                          | 1.7                                       | Criterion               |
|         |         | 133         | 9576                    |                    | 1                     | 2                        | 3            | 1.63                         | 4.14                                    | 129                          | 4.9                                       |                         |
|         |         | 134         | 9648                    |                    | 0                     | 0                        | 0            | 2.67                         | -                                       | 192                          | 0                                         | Criterion               |
|         |         | 135         | 9720                    |                    | 0                     | 0                        | 0            | 2.89                         | -                                       | 208                          | 0                                         | Criterion               |
|         |         | 136         | 9792                    |                    | 1                     | 1                        | 2            | 2.02                         | 8.34                                    | 161                          | 4.0                                       |                         |
|         |         | 137         | 9864                    |                    | 1                     | 2                        | 3            | 1.76                         | 2.08                                    | 133                          | 5.3                                       |                         |
|         |         | 138         | 9936                    |                    | 0                     | 2                        | 2            | 2.33                         | 2.68                                    | 173                          | 4.7                                       |                         |

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Paula (cont)

| DATE     | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX:<br>MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES                                                             |
|----------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|----------------------------------------------|---------------------------------------------------------------------------------|
| 9 March  | 8       | 139         | 10,008                  | S                  | 0                     | 2                        | 2            | 1.98                         | 1.78                                    | 146                          | 4.0                                          | Criterion<br>.61 hours                                                          |
|          |         | 140         | 10,080                  |                    | 1                     | 2                        | 3            | 2.42                         | 2.98                                    | 183                          | 7.3                                          |                                                                                 |
|          |         | 141         | 10,152                  |                    | 1                     | 2                        | 3            | 2.01                         | 2.25                                    | 151                          | 6.0                                          |                                                                                 |
|          |         | 142         | 10,224                  |                    | 1                     | 1                        | 2            | 2.17                         | 1.45                                    | 159                          | 4.3                                          |                                                                                 |
|          |         | 143         | 10,296                  |                    | 0                     | 2                        | 2            | 1.95                         | 1.23                                    | 142                          | 3.9                                          |                                                                                 |
|          |         | 144         | 10,368                  |                    | 0                     | 1                        | 1            | 2.20                         | 1.39                                    | 159                          | 2.2                                          |                                                                                 |
|          |         | 145         | 10,440                  |                    | 1                     | 1                        | 2            | 1.95                         | 2.87                                    | 146                          | 3.9                                          |                                                                                 |
| 14 March | 13      | 146         | 10,512                  | D                  | 2                     | 10                       | 12           | 3.14                         | 5.88                                    | 297                          | 38                                           | O instructed to<br>alternate<br>laterality of<br>initial gaze<br><br>1.13 hours |
|          |         | 147         | 10,584                  |                    | 4                     | 11                       | 15           | 4.45                         | 5.16                                    | 397                          | 67                                           |                                                                                 |
|          |         | 148         | 10,656                  |                    | 4                     | 13                       | 17           | 3.24                         | 3.66                                    | 295                          | 58                                           |                                                                                 |
|          |         | 149         | 10,728                  |                    | 4                     | 7                        | 11           | 4.60                         | 3.51                                    | 370                          | 51                                           |                                                                                 |
|          |         | 150         | 10,800                  |                    | 1                     | 7                        | 8            | 2.87                         | 6.06                                    | 255                          | 23                                           |                                                                                 |
|          |         | 151         | 10,872                  |                    | 2                     | 7                        | 9            | 3.58                         | 4.65                                    | 300                          | 32                                           |                                                                                 |
|          |         | 152         | 10,944                  |                    | 0                     | 9                        | 9            | 3.16                         | 2.12                                    | 247                          | 28                                           |                                                                                 |
|          |         | 153         | 11,016                  |                    | 2                     | 4                        | 6            | 4.34                         | 1.61                                    | 322                          | 26                                           |                                                                                 |
|          |         | 154         | 11,088                  |                    | 2                     | 6                        | 8            | 2.94                         | 2.73                                    | 234                          | 24                                           |                                                                                 |
|          |         | 155         | 11,160                  |                    | 4                     | 9                        | 13           | 3.48                         | 3.26                                    | 293                          | 45                                           |                                                                                 |
|          |         | 156         | 11,232                  |                    | 2                     | 6                        | 8            | 2.95                         | 2.90                                    | 235                          | 24                                           |                                                                                 |
|          |         | 157         | 11,304                  |                    | 1                     | 4                        | 5            | 3.67                         | 4.49                                    | 287                          | 18                                           |                                                                                 |
|          |         | 158         | 11,376                  |                    | 0                     | 6                        | 6            | 3.26                         | 5.76                                    | 269                          | 20                                           |                                                                                 |
|          |         | 159         | 11,448                  |                    | 1                     | 6                        | 7            | 3.65                         | 1.90                                    | 276                          | 26                                           |                                                                                 |

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Paula (cont)

| DATE     | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES     |
|----------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|-------------------------|
| 15 March | 14      | 160         | 11,520                  | D                  | 3                     | 9                        | 12           | 2.65                         | 2.84                                    | 225                          | 32                                        | 1.22 hours              |
|          |         | 161         | 11,592                  |                    | 1                     | 8                        | 9            | 3.81                         | 5.44                                    | 324                          | 34                                        |                         |
|          |         | 162         | 11,664                  |                    | 0                     | 5                        | 5            | 3.79                         | 4.70                                    | 296                          | 19                                        |                         |
|          |         | 163         | 11,736                  |                    | 0                     | 4                        | 4            | 4.07                         | 4.30                                    | 310                          | 16                                        |                         |
|          |         | 164         | 11,808                  |                    | 0                     | 1                        | 1            | 4.25                         | 3.48                                    | 309                          | 4.3                                       |                         |
|          |         | 165         | 11,880                  |                    | 1                     | 1                        | 2            | 4.21                         | 6.24                                    | 315                          | 8.4                                       |                         |
|          |         | 166         | 11,952                  |                    | 1                     | 3                        | 4            | 3.64                         | 3.61                                    | 276                          | 15                                        |                         |
|          |         | 167         | 12,024                  |                    | 1                     | 1                        | 2            | 3.27                         | 3.22                                    | 241                          | 6.5                                       |                         |
|          |         | 168         | 12,096                  |                    | 1                     | 2                        | 3            | 3.17                         | 2.29                                    | 235                          | 9.5                                       |                         |
|          |         | 169         | 12,168                  |                    | 1                     | 4                        | 5            | 3.73                         | 2.57                                    | 282                          | 19                                        |                         |
|          |         | 170         | 12,240                  |                    | 4                     | 4                        | 8            | 3.39                         | 3.09                                    | 262                          | 27                                        |                         |
|          |         | 171         | 12,312                  |                    | 2                     | 4                        | 6            | 3.53                         | 3.21                                    | 273                          | 21                                        |                         |
|          |         | 172         | 12,384                  |                    | 0                     | 3                        | 3            | 3.39                         | 4.52                                    | 257                          | 10                                        |                         |
|          |         | 173         | 12,456                  |                    | 1                     | 2                        | 3            | 3.66                         | 3.47                                    | 274                          | 11                                        |                         |
|          |         | 174         | 12,528                  |                    | 0                     | 3                        | 3            | 3.18                         | 3.67                                    | 239                          | 10                                        |                         |
|          |         | 175         | 12,600                  |                    | 0                     | 2                        | 2            | 3.53                         | 2.77                                    | 259                          | 7.1                                       |                         |
| 16 March | 15      | 176         | 12,672                  | D                  | 2                     | 3                        | 5            | 3.21                         | 3.35                                    | 247                          | 16                                        | Criterion<br>1.04 hours |
|          |         | 177         | 12,744                  |                    | 0                     | 4                        | 4            | 3.29                         | 5.18                                    | 257                          | 13                                        |                         |
|          |         | 178         | 12,816                  |                    | 0                     | 3                        | 3            | 2.97                         | 2.76                                    | 222                          | 8.9                                       |                         |
|          |         | 179         | 12,888                  |                    | 3                     | 3                        | 6            | 3.20                         | 4.73                                    | 259                          | 19                                        |                         |
|          |         | 180         | 12,960                  |                    | 0                     | 5                        | 5            | 2.79                         | 5.27                                    | 227                          | 14                                        |                         |
|          |         | 181         | 13,032                  |                    | 0                     | 1                        | 1            | 3.03                         | 5.04                                    | 223                          | 3.0                                       |                         |
|          |         | 182         | 13,104                  |                    | 0                     | 3                        | 3            | 2.52                         | 4.89                                    | 196                          | 7.6                                       |                         |
|          |         | 183         | 13,176                  |                    | 1                     | 1                        | 2            | 2.63                         | 3.27                                    | 195                          | 5.3                                       |                         |
|          |         | 184         | 13,248                  |                    | 2                     | 2                        | 4            | 2.75                         | 3.01                                    | 210                          | 11                                        |                         |
|          |         | 185         | 13,320                  |                    | 1                     | 4                        | 5            | 3.08                         | 5.36                                    | 248                          | 15                                        |                         |
|          |         | 186         | 13,392                  |                    | 0                     | 1                        | 1            | 2.95                         | 7.06                                    | 219                          | 3.0                                       |                         |
|          |         | 187         | 13,464                  |                    | 0                     | 1                        | 1            | 3.01                         | 6.79                                    | 224                          | 3.0                                       |                         |
|          |         | 188         | 13,536                  |                    | 0                     | 3                        | 3            | 2.66                         | 4.63                                    | 206                          | 8.0                                       |                         |
|          |         | 189         | 13,608                  |                    | 0                     | 3                        | 3            | 3.02                         | 1.22                                    | 220                          | 9.0                                       |                         |
|          |         | 190         | 13,680                  |                    | 1                     | 4                        | 5            | 2.72                         | 3.25                                    | 213                          | 14                                        |                         |
|          |         | 191         | 13,752                  |                    | 1                     | 1                        | 2            | 2.67                         | 1.83                                    | 196                          | 5.3                                       |                         |
|          |         | 192         | 13,824                  |                    | 0                     | 1                        | 1            | 2.62                         | 4.55                                    | 194                          | 2.6                                       |                         |

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Paula (cont)

| DATE     | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES |
|----------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|---------------------|
| 17 March | 16      | 193         | 13,896                  | D                  | 2                     | 4                        | 6            | 2.68                         | 3.33                                    | 212                          | 16                                        | .87 hours           |
|          |         | 194         | 13,968                  |                    | 2                     | 2                        | 4            | 2.42                         | 1.99                                    | 182                          | 10                                        |                     |
|          |         | 195         | 14,040                  |                    | 0                     | 2                        | 2            | 2.73                         | 2.23                                    | 202                          | 5.5                                       |                     |
|          |         | 196         | 14,112                  |                    | 1                     | 5                        | 6            | 2.72                         | 3.40                                    | 216                          | 16                                        |                     |
|          |         | 197         | 14,184                  |                    | 0                     | 1                        | 1            | 3.05                         | 4.21                                    | 224                          | 3.0                                       |                     |
|          |         | 198         | 14,256                  |                    | 1                     | 5                        | 6            | 3.25                         | 2.32                                    | 247                          | 20                                        |                     |
|          |         | 199         | 14,328                  |                    | 1                     | 1                        | 2            | 3.57                         | 6.04                                    | 269                          | 7.1                                       |                     |
|          |         | 200         | 14,400                  |                    | 0                     | 3                        | 3            | 2.57                         | 6.48                                    | 206                          | 7.7                                       |                     |
|          |         | 201         | 14,472                  |                    | 2                     | 2                        | 4            | 2.63                         | 2.19                                    | 198                          | 11                                        |                     |
|          |         | 202         | 14,544                  |                    | 1                     | 6                        | 7            | 2.78                         | 1.65                                    | 211                          | 20                                        |                     |
|          |         | 203         | 14,616                  |                    | 1                     | 1                        | 2            | 2.50                         | 1.12                                    | 182                          | 5.0                                       |                     |
|          |         | 204         | 14,688                  |                    | 3                     | 3                        | 6            | 2.57                         | 2.21                                    | 198                          | 15                                        |                     |
|          |         | 205         | 14,760                  |                    | 1                     | 4                        | 5            | 2.66                         | 1.61                                    | 200                          | 13                                        |                     |
|          |         | 206         | 14,832                  |                    | 1                     | 5                        | 6            | 2.41                         | 2.60                                    | 190                          | 14                                        |                     |
|          |         | 207         | 14,904                  |                    | 2                     | 2                        | 4            | 2.68                         | 1.75                                    | 200                          | 11                                        |                     |
| 20 March | 19      | 208         | 14,976                  | D                  | 1                     | 4                        | 5            | 3.31                         | 2.28                                    | 249                          | 16                                        | .94 hours           |
|          |         | 209         | 15,048                  |                    | 2                     | 2                        | 4            | 2.74                         | 1.43                                    | 203                          | 11                                        |                     |
|          |         | 210         | 15,120                  |                    | 2                     | 4                        | 6            | 2.50                         | 1.81                                    | 191                          | 15                                        |                     |
|          |         | 211         | 15,192                  |                    | 3                     | 1                        | 4            | 2.43                         | 1.74                                    | 180                          | 7.2                                       |                     |
|          |         | 212         | 15,264                  |                    | 2                     | 2                        | 4            | 2.53                         | 3.77                                    | 197                          | 10                                        |                     |
|          |         | 213         | 15,336                  |                    | 5                     | 1                        | 6            | 2.54                         | 1.59                                    | 192                          | 15                                        |                     |
|          |         | 214         | 15,408                  |                    | 2                     | 1                        | 3            | 2.27                         | 1.10                                    | 166                          | 6.8                                       |                     |
|          |         | 215         | 15,480                  |                    | 0                     | 2                        | 2            | 1.87                         | 0.80                                    | 137                          | 3.7                                       |                     |
|          |         | 216         | 15,552                  |                    | 3                     | 2                        | 5            | 2.15                         | 1.50                                    | 162                          | 11                                        |                     |
|          |         | 217         | 15,624                  |                    | 1                     | 1                        | 2            | 1.97                         | 0.85                                    | 144                          | 3.9                                       |                     |
|          |         | 218         | 15,696                  |                    | 1                     | 2                        | 3            | 1.88                         | 1.20                                    | 139                          | 5.6                                       |                     |
|          |         | 219         | 15,768                  |                    | 1                     | 3                        | 4            | 1.92                         | 1.28                                    | 143                          | 7.7                                       |                     |
|          |         | 220         | 15,840                  |                    | 1                     | 3                        | 4            | 1.97                         | 0.88                                    | 146                          | 7.9                                       |                     |
|          |         | 221         | 15,912                  |                    | 4                     | 3                        | 7            | 2.04                         | 0.93                                    | 154                          | 14                                        |                     |
|          |         | 222         | 15,984                  |                    | 1                     | 4                        | 5            | 1.90                         | 0.88                                    | 142                          | 9.5                                       |                     |
|          |         | 223         | 16,056                  |                    | 0                     | 3                        | 3            | 2.06                         | 0.78                                    | 150                          | 6.2                                       |                     |
|          |         | 224         | 16,128                  |                    | 3                     | 8                        | 11           | 2.10                         | 1.44                                    | 167                          | 23                                        |                     |
|          |         | 225         | 16,200                  |                    | 3                     | 1                        | 4            | 2.44                         | 1.57                                    | 182                          | 9.8                                       |                     |
|          |         | 226         | 16,272                  |                    | 2                     | 4                        | 6            | 2.09                         | 1.42                                    | 158                          | 13                                        |                     |
|          |         | 227         | 16,344                  |                    | 0                     | 5                        | 5            | 2.18                         | 1.46                                    | 164                          | 11                                        |                     |





GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA  
(Culled from computer printout)

Subject: Kathryn

| DATE     | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES                                                           |
|----------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|-------------------------------------------------------------------------------|
| 18 April | 12      | 1           | 72                      | S                  | 7                     | 14                       | 21           | 21.90                        | 20.48                                   | 2007                         | 460                                       | Original set of 9 colours<br><br>* D randomization used on error              |
|          |         | 2           | 144                     | S                  | 7                     | 11                       | 18           | 7.96                         | 6.65                                    | 693                          | 143                                       |                                                                               |
|          |         | 3           | 216                     | S                  | 5                     | 8                        | 13           | 5.29                         | 4.30                                    | 437                          | 69                                        |                                                                               |
|          |         | 4           | 288                     | S                  | 4                     | 11                       | 15           | 4.13                         | 4.39                                    | 363                          | 62                                        |                                                                               |
|          |         | 5           | 360                     | S                  | 2                     | 7                        | 9            | 3.36                         | 3.40                                    | 273                          | 30                                        |                                                                               |
|          |         | 6           | 432                     | S                  | 2                     | 14                       | 16           | 3.41                         | 3.67                                    | 305                          | 55                                        |                                                                               |
|          |         | 7           | 504                     | S                  | 0                     | 9                        | 9            | 3.04                         | 2.76                                    | 244                          | 27                                        |                                                                               |
|          |         | 8           | 576                     | S                  | 6                     | 7                        | 13           | 3.07                         | 2.56                                    | 254                          | 40                                        |                                                                               |
|          |         | 9           | 648                     | S                  | 1                     | 9                        | 10           | 2.85                         | 2.39                                    | 229                          | 29                                        |                                                                               |
|          |         | 10          | 720                     | S                  | 2                     | 7                        | 9            | 3.01                         | 2.18                                    | 237                          | 27                                        |                                                                               |
|          |         | 11          | 792                     | D*                 | 1                     | 19                       | 20           | 3.19                         | 2.95                                    | 289                          | 64                                        |                                                                               |
|          |         | 12          | 864                     | S                  | 4                     | 5                        | 9            | 3.21                         | 2.36                                    | 252                          | 29                                        |                                                                               |
|          |         | 13          | 936                     | S                  | 2                     | 9                        | 11           | 3.13                         | 2.30                                    | 250                          | 34                                        |                                                                               |
|          |         | 14          | 1008                    | S                  | 0                     | 4                        | 4            | 2.98                         | 1.73                                    | 222                          | 16                                        |                                                                               |
|          |         | 15          | 1080                    | S                  | 2                     | 9                        | 11           | 2.82                         | 2.88                                    | 235                          | 31                                        |                                                                               |
|          |         | 16          | 1152                    | S                  | 0                     | 6                        | 6            | 2.97                         | 2.22                                    | 227                          | 18                                        |                                                                               |
|          |         | 17          | 1224                    | S                  | 2                     | 10                       | 12           | 2.95                         | 2.32                                    | 240                          | 34                                        |                                                                               |
|          |         | 18          | 1296                    | S                  | 0                     | 6                        | 6            | 2.77                         | 2.27                                    | 213                          | 17                                        |                                                                               |
|          |         | 19          | 1368                    | S                  | 0                     | 3                        | 3            | 2.51                         | 1.92                                    | 191                          | 7.5                                       |                                                                               |
| 20 April | 14      | 20          | 1440                    | S                  | 5                     | 6                        | 11           | 4.08                         | 4.08                                    | 339                          | 45                                        | Original 9 colours in subtractive combination with filter no.36.<br>.41 hours |
|          |         | 21          | 1512                    |                    | 1                     | 7                        | 8            | 2.77                         | 3.43                                    | 226                          | 22                                        |                                                                               |
|          |         | 22          | 1584                    |                    | 4                     | 3                        | 7            | 2.62                         | 3.33                                    | 212                          | 18                                        |                                                                               |
|          |         | 23          | 1656                    |                    | 1                     | 5                        | 6            | 2.71                         | 3.56                                    | 216                          | 16                                        |                                                                               |
|          |         | 24          | 1728                    |                    | 1                     | 4                        | 5            | 2.46                         | 2.64                                    | 190                          | 12                                        |                                                                               |
|          |         | 25          | 1800                    |                    | 2                     | 4                        | 6            | 2.47                         | 2.83                                    | 295                          | 15                                        |                                                                               |
|          | 15      | 26          | 1872                    |                    | 3                     | 5                        | 8            | 2.83                         | 4.72                                    | 242                          | 23                                        | Filter no. 23<br><br>.86 hours                                                |
|          |         | 27          | 1944                    |                    | 1                     | 5                        | 6            | 2.35                         | 3.17                                    | 188                          | 14                                        |                                                                               |
|          |         | 28          | 2016                    |                    | 2                     | 6                        | 8            | 2.47                         | 2.97                                    | 202                          | 20                                        |                                                                               |
|          |         | 29          | 2088                    |                    | 1                     | 4                        | 5            | 2.39                         | 3.02                                    | 187                          | 12                                        |                                                                               |
|          |         | 30          | 2160                    |                    | 0                     | 3                        | 3            | 2.32                         | 2.83                                    | 175                          | 7.0                                       |                                                                               |
|          |         | 31          | 2232                    |                    | 1                     | 1                        | 2            | 2.44                         | 2.26                                    | 181                          | 4.9                                       |                                                                               |
|          |         | 32          | 2304                    |                    | 2                     | 1                        | 3            | 2.59                         | 2.52                                    | 194                          | 7.8                                       |                                                                               |
|          |         | 33          | 2376                    | S                  | 13                    | 14                       | 27           | 6.15                         | 8.45                                    | 671                          | 166                                       |                                                                               |
|          |         | 34          | 2448                    |                    | 7                     | 11                       | 18           | 4.56                         | 6.76                                    | 450                          | 82                                        |                                                                               |
|          |         | 35          | 2520                    |                    | 4                     | 7                        | 11           | 3.69                         | 4.75                                    | 318                          | 41                                        |                                                                               |
|          |         | 36          | 2592                    |                    | 7                     | 6                        | 13           | 3.38                         | 4.56                                    | 302                          | 44                                        |                                                                               |

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Kathryn (cont)

| DATE     | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES                                         |
|----------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|-------------------------------------------------------------|
| 24 April | 18      | 37          | 2664                    | S                  | 6                     | 5                        | 11           | 3.01                         | 4.54                                    | 267                          | 33                                        | Filter no. 40                                               |
|          |         | 38          | 2736                    |                    | 2                     | 1                        | 3            | 2.60                         | 4.04                                    | 199                          | 7.8                                       |                                                             |
|          |         | 39          | 2808                    |                    | 2                     | 3                        | 5            | 2.70                         | 4.55                                    | 217                          | 14                                        |                                                             |
|          |         | 40          | 2880                    |                    | 3                     | 3                        | 6            | 2.62                         | 4.22                                    | 214                          | 13                                        |                                                             |
|          |         | 41          | 2952                    |                    | 2                     | 3                        | 5            | 2.53                         | 4.36                                    | 204                          | 13                                        |                                                             |
|          |         | 42          | 3024                    |                    | 3                     | 4                        | 7            | 2.60                         | 3.37                                    | 211                          | 18                                        |                                                             |
|          |         | 43          | 3096                    |                    | 4                     | 3                        | 7            | 2.42                         | 4.02                                    | 202                          | 17                                        |                                                             |
|          |         | 44          | 3168                    |                    | 3                     | 2                        | 5            | 2.49                         | 3.69                                    | 197                          | 12                                        |                                                             |
|          |         | 45          | 3240                    |                    | 0                     | 2                        | 2            | 2.37                         | 5.62                                    | 182                          | 4.7                                       |                                                             |
|          |         | 46          | 3312                    |                    | 1                     | 2                        | 3            | 2.62                         | 2.92                                    | 198                          | 7.9                                       |                                                             |
| 25 April | 19      | 47          | 3384                    | D                  | 4                     | 2                        | 6            | 2.48                         | 3.62                                    | 201                          | 15                                        | Original 9 colours (no filter inter-posed)<br><br>.62 hours |
|          |         | 48          | 3456                    |                    | 7                     | 12                       | 19           | 3.66                         | 6.47                                    | 387                          | 61                                        |                                                             |
|          |         | 49          | 3528                    |                    | 2                     | 9                        | 11           | 3.15                         | 4.76                                    | 279                          | 35                                        |                                                             |
|          |         | 50          | 3600                    |                    | 4                     | 8                        | 12           | 2.90                         | 4.73                                    | 266                          | 35                                        |                                                             |
|          |         | 51          | 3672                    |                    | 1                     | 6                        | 7            | 2.67                         | 4.10                                    | 221                          | 19                                        |                                                             |
|          |         | 52          | 3744                    |                    | 1                     | 6                        | 7            | 2.70                         | 3.64                                    | 219                          | 19                                        |                                                             |
|          |         | 53          | 3816                    |                    | 3                     | 8                        | 11           | 2.41                         | 4.00                                    | 218                          | 27                                        |                                                             |
|          |         | 54          | 3888                    |                    | 4                     | 5                        | 9            | 2.58                         | 3.64                                    | 219                          | 23                                        |                                                             |
|          |         | 55          | 3960                    |                    | 3                     | 6                        | 9            | 2.60                         | 4.62                                    | 229                          | 23                                        |                                                             |
|          |         | 56          | 4032                    |                    | 3                     | 6                        | 9            | 2.47                         | 3.42                                    | 209                          | 23                                        |                                                             |
| 27 April | 21      | 57          | 4104                    | D                  | 5                     | 14                       | 19           | 3.77                         | 6.03                                    | 386                          | 72                                        | Filter no. 36                                               |
|          |         | 58          | 4176                    |                    | 5                     | 9                        | 14           | 3.04                         | 4.96                                    | 288                          | 43                                        |                                                             |
|          |         | 59          | 4248                    |                    | 5                     | 8                        | 13           | 2.79                         | 4.26                                    | 256                          | 36                                        |                                                             |
|          |         | 60          | 4320                    |                    | 5                     | 4                        | 9            | 2.80                         | 3.98                                    | 238                          | 25                                        |                                                             |
|          |         | 61          | 4392                    |                    | 2                     | 8                        | 10           | 2.69                         | 3.65                                    | 231                          | 27                                        |                                                             |
|          |         | 62          | 4464                    |                    | 4                     | 9                        | 13           | 2.58                         | 3.65                                    | 231                          | 34                                        |                                                             |
|          |         | 63          | 4536                    |                    | 4                     | 6                        | 10           | 2.56                         | 3.55                                    | 210                          | 26                                        |                                                             |
|          |         | 64          | 4608                    |                    | 3                     | 5                        | 8            | 2.67                         | 2.93                                    | 215                          | 21                                        |                                                             |
| 28 April | 22      | 65          | 4680                    | D                  | 3                     | 14                       | 17           | 3.11                         | 4.21                                    | 296                          | 53                                        | Filter no. 40                                               |
|          |         | 66          | 4752                    |                    | 3                     | 5                        | 8            | 2.58                         | 4.21                                    | 220                          | 21                                        |                                                             |
|          |         | 67          | 4824                    |                    | 6                     | 11                       | 17           | 2.76                         | 4.31                                    | 272                          | 47                                        |                                                             |
|          |         | 68          | 4896                    |                    | 4                     | 11                       | 15           | 2.86                         | 4.27                                    | 270                          | 43                                        |                                                             |
|          |         | 69          | 4968                    |                    | 3                     | 7                        | 10           | 2.61                         | 3.55                                    | 224                          | 26                                        |                                                             |
|          |         | 70          | 5040                    |                    | 3                     | 4                        | 7            | 2.46                         | 4.00                                    | 204                          | 17                                        |                                                             |



GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA  
(Culled from computer printout)

Subject: Kathryn (cont)

| DATE   | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES  |
|--------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|----------------------|
| 12 May | 36      | 106         | 7632                    | S                  | 2                     | 2                        | 4            | 2.11                         | 3.96                                    | 168                          | 8.4                                       | <u>Filter 36</u>     |
|        |         | 107         | 7704                    |                    | 0                     | 2                        | 2            | 2.16                         | 3.50                                    | 163                          | 4.5                                       |                      |
|        |         | 108         | 7776                    |                    | 0                     | 0                        | 0            | 2.17                         | -                                       | 156                          | 0                                         | Criterion            |
|        |         | 109         | 7848                    |                    | 1                     | 0                        | 1            | 2.20                         | 7.02                                    | 165                          | 2.2                                       | Criterion            |
|        |         | 110         | 7920                    |                    | 0                     | 0                        | 0            | 2.13                         | -                                       | 153                          | 0                                         | Criterion            |
|        |         | 111         | 7992                    |                    | 0                     | 0                        | 0            | 2.16                         | -                                       | 156                          | 0                                         | Criterion            |
|        |         | 112         | 8064                    |                    | 0                     | 1                        | 1            | 2.22                         | 3.87                                    | 164                          | 2.2                                       | Criterion            |
|        | 39      | 113         | 8136                    | D                  | 1                     | 8                        | 9            | 2.51                         | 5.47                                    | 230                          | 23                                        | <u>Filter 36</u>     |
|        |         | 114         | 8208                    |                    | 1                     | 2                        | 3            | 2.53                         | 4.67                                    | 196                          | 7.6                                       |                      |
|        |         | 115         | 8280                    |                    | 0                     | 0                        | 0            | 2.38                         | -                                       | 171                          | 0                                         | Criterion            |
|        |         | 116         | 8352                    |                    | 0                     | 0                        | 0            | 2.33                         | -                                       | 168                          | 0                                         | Criterion            |
|        |         | 117         | 8424                    |                    | 0                     | 1                        | 1            | 2.28                         | 4.24                                    | 168                          | 2.3                                       | Criterion            |
|        |         |             |                         |                    |                       |                          |              |                              |                                         |                              |                                           | .57 hours            |
| 15 May | 39      | 118         | 8496                    | S                  | 6                     | 0                        | 6            | 2.47                         | 4.99                                    | 208                          | 15                                        | <u>Filter 69</u>     |
|        |         | 119         | 8568                    |                    | 3                     | 0                        | 3            | 2.32                         | 5.54                                    | 184                          | 7.0                                       |                      |
|        |         | 120         | 8640                    |                    | 1                     | 1                        | 2            | 2.24                         | 4.01                                    | 169                          | 4.5                                       |                      |
|        |         | 121         | 8712                    |                    | 0                     | 1                        | 1            | 2.20                         | 2.75                                    | 161                          | 2.2                                       | Criterion            |
|        |         | 122         | 8784                    |                    | 0                     | 0                        | 0            | 2.20                         | -                                       | 158                          | 0                                         | Criterion            |
|        |         | 123         | 8856                    |                    | 0                     | 0                        | 0            | 2.34                         | -                                       | 168                          | 0                                         | Criterion            |
|        |         | 124         | 8928                    |                    | 0                     | 0                        | 0            | 2.21                         | -                                       | 159                          | 0                                         | Criterion            |
|        |         | 125         | 9000                    |                    | 1                     | 0                        | 1            | 2.27                         | 5.86                                    | 169                          | 2.3                                       | Criterion            |
|        |         |             |                         |                    |                       |                          |              |                              |                                         |                              |                                           | <u>Filter 69</u>     |
|        |         | 126         | 9072                    | D                  | 0                     | 0                        | 0            | 2.44                         | -                                       | 176                          | 0                                         | Criterion            |
|        | 40      | 127         | 9144                    |                    | 0                     | 2                        | 2            | 2.44                         | 3.43                                    | 183                          | 4.9                                       |                      |
|        |         | 128         | 9216                    |                    | 0                     | 1                        | 1            | 2.70                         | 3.94                                    | 198                          | 2.7                                       |                      |
|        |         | 129         | 9288                    |                    | 0                     | 0                        | 0            | 2.62                         | -                                       | 189                          | 0                                         | Criterion            |
|        |         | 130         | 9360                    |                    | 0                     | 0                        | 0            | 2.51                         | -                                       | 181                          | 0                                         | Criterion            |
|        |         |             |                         |                    |                       |                          |              |                              |                                         |                              |                                           |                      |
| 16 May | 40      | 131         | 9432                    | S                  | 5                     | 2                        | 7            | 3.01                         | 6.34                                    | 261                          | 21                                        | <u>Filters 40-23</u> |
|        |         | 132         | 9504                    |                    | 1                     | 1                        | 2            | 2.50                         | 4.10                                    | 188                          | 5.0                                       |                      |
|        |         | 133         | 9576                    |                    | 0                     | 1                        | 1            | 2.26                         | 3.58                                    | 167                          | 2.3                                       | Criterion            |
|        |         | 134         | 9648                    |                    | 0                     | 2                        | 2            | 2.09                         | 3.41                                    | 157                          | 4.2                                       |                      |
|        |         | 135         | 9720                    |                    | 1                     | 1                        | 2            | 4.50                         | 5.68                                    | 173                          | 4.5                                       |                      |
|        |         | 136         | 9792                    |                    | 1                     | 0                        | 1            | 2.22                         | 4.70                                    | 169                          | 2.2                                       | Criterion            |
|        |         | 137         | 9864                    |                    | 1                     | 1                        | 2            | 2.12                         | 3.91                                    | 161                          | 4.2                                       |                      |

## GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA

(Culled from computer printout)

Subject: Kathryn (cont)

| DATE   | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX: MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES |
|--------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|-------------------------------------------|---------------------|
| 16 May | 40      | 138         | 9,936                   | S                  | 1                     | 0                        | 1            | 2.08                         | 4.53                                    | 155                          | 2.1                                       | Filter 40           |
|        |         | 139         | 10,008                  |                    | 0                     | 1                        | 1            | 2.11                         | 3.54                                    | 156                          | 2.1                                       | Criterion           |
|        |         | 140         | 10,080                  |                    | 1                     | 1                        | 2            | 2.13                         | 3.34                                    | 160                          | 4.3                                       | Criterion           |
|        |         | 141         | 10,152                  |                    | 1                     | 1                        | 2            | 2.27                         | 4.05                                    | 171                          | 4.5                                       | .53 hours           |
| 17 May | 41      | 142         | 10,224                  | D                  | 1                     | 7                        | 8            | 2.59                         | 8.06                                    | 250                          | 21                                        | Filters 40-23       |
|        |         | 143         | 10,296                  |                    | 2                     | 3                        | 5            | 2.31                         | 6.37                                    | 197                          | 12                                        |                     |
|        |         | 144         | 10,368                  |                    | 0                     | 1                        | 1            | 2.02                         | 5.39                                    | 150                          | 2.0                                       | Criterion           |
|        |         | 145         | 10,440                  |                    | 1                     | 0                        | 1            | 2.11                         | 4.10                                    | 156                          | 2.1                                       | Criterion           |
|        |         | 146         | 10,512                  |                    | 3                     | 0                        | 3            | 2.20                         | 5.04                                    | 173                          | 6.6                                       |                     |
|        |         | 147         | 10,584                  |                    | 3                     | 1                        | 4            | 2.15                         | 4.44                                    | 173                          | 8.6                                       |                     |
|        |         | 148         | 10,656                  |                    | 2                     | 2                        | 4            | 2.32                         | 4.85                                    | 186                          | 9.3                                       |                     |
|        |         | 149         | 10,728                  |                    | 0                     | 0                        | 0            | 2.18                         | -                                       | 157                          | 0                                         | Criterion           |
|        |         | 150         | 10,800                  |                    | 1                     | 3                        | 4            | 2.34                         | 3.88                                    | 183                          | 9.3                                       | 0.45 hours          |
|        |         |             |                         |                    |                       |                          |              |                              |                                         |                              |                                           |                     |
| 18 May | 42      | 151         | 10,872                  | S                  | 10                    | 6                        | 16           | 2.96                         | 6.33                                    | 314                          | 47                                        | Filter no. 1        |
|        |         | 152         | 10,944                  |                    | 4                     | 2                        | 6            | 2.70                         | 6.02                                    | 230                          | 16                                        |                     |
|        |         | 153         | 11,016                  |                    | 0                     | 4                        | 4            | 2.30                         | 5.78                                    | 189                          | 9.2                                       |                     |
|        |         | 154         | 11,088                  |                    | 1                     | 3                        | 4            | 2.33                         | 3.81                                    | 183                          | 9.3                                       |                     |
|        |         | 155         | 11,160                  |                    | 4                     | 1                        | 5            | 2.22                         | 4.25                                    | 181                          | 11                                        |                     |
|        |         | 156         | 11,232                  |                    | 3                     | 2                        | 5            | 2.31                         | 4.38                                    | 188                          | 12                                        |                     |
|        |         | 157         | 11,304                  |                    | 0                     | 3                        | 3            | 2.14                         | 4.12                                    | 166                          | 6.4                                       |                     |
|        |         | 158         | 11,376                  |                    | 2                     | 3                        | 5            | 2.17                         | 3.43                                    | 172                          | 11                                        |                     |
|        |         | 159         | 11,448                  |                    | 1                     | 2                        | 3            | 2.14                         | 3.27                                    | 164                          | 6.4                                       | 0.50 hours          |
|        |         |             |                         |                    |                       |                          |              |                              |                                         |                              |                                           |                     |
| 19 May | 43      | 160         | 11,520                  | S                  | 9                     | 6                        | 15           | 2.56                         | 5.22                                    | 262                          | 38                                        | Filters 1-36        |
|        |         | 161         | 11,592                  |                    | 2                     | 3                        | 5            | 2.44                         | 4.28                                    | 197                          | 12                                        |                     |
|        |         | 162         | 11,664                  |                    | 3                     | 2                        | 5            | 2.48                         | 4.21                                    | 200                          | 12                                        |                     |
|        |         | 163         | 11,736                  |                    | 1                     | 2                        | 3            | 2.37                         | 4.09                                    | 183                          | 7.1                                       |                     |
|        |         | 164         | 11,808                  |                    | 1                     | 2                        | 3            | 2.36                         | 3.29                                    | 180                          | 7.1                                       |                     |
|        |         | 165         | 11,880                  |                    | 1                     | 2                        | 3            | 2.42                         | 3.80                                    | 184                          | 7.3                                       |                     |
|        |         | 166         | 11,952                  |                    | 1                     | 4                        | 5            | 2.47                         | 2.66                                    | 191                          | 12                                        |                     |
|        |         | 167         | 12,024                  |                    | 3                     | 2                        | 5            | 2.45                         | 4.48                                    | 199                          | 12                                        |                     |
|        |         | 168         | 12,096                  |                    | 3                     | 1                        | 4            | 2.39                         | 4.01                                    | 188                          | 9.6                                       |                     |
|        |         | 169         | 12,168                  |                    | 2                     | 3                        | 5            | 2.43                         | 4.13                                    | 196                          | 12                                        |                     |
|        |         | 170         | 12,240                  |                    | 2                     | 1                        | 3            | 2.36                         | 3.25                                    | 180                          | 7.1                                       | .60 hours           |

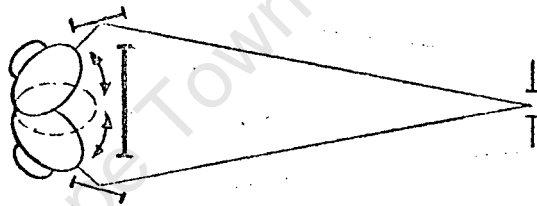


CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATASUBJECT: PaulaDATE: March 2

DISTRIBUTIONS OF OPEN-ENDED RESPONSES (CONTINGENT ON SPECIFIC VIEWING CONDITIONS) TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER HUE-TRANSITION RANGE.

Refer to Data Sheet 1, p.

Day No. 1

Serial Status of Test: Pre-experimentalPurpose: (Informal) testing for laterality bias in viewing system.Method of Single Stimuli, open-ended judgmentsViewing Conditions: As shown

|                |    | Gaze-Left     |               | Gaze-Right   |              |
|----------------|----|---------------|---------------|--------------|--------------|
|                |    | 1st Sequence  | 2nd Sequence  | 1st Sequence | 2nd Sequence |
| Max. Red = 0   | 45 | pink          | pink          | pink         | pink         |
|                | 46 | pink          | pink          | pink         | pink         |
| Vernier        | 47 | pinkish       | pink          | pink         | v. pale do.  |
| settings       | 48 | neither       | grey          | pinky grey   | pale grey    |
| of             | 49 | neither, + G? | v. pale green | neither      | greyish      |
| colour-        | 50 | greenish      | greenish      | neither      | grey         |
| mixer          | 51 | green         | green         | grey         | grey         |
| (0-100)        | 53 | green         | green         | green        | green        |
|                | 55 | green         | green         | green        | green        |
| Max. B-G = 100 | 60 | green         | green         | green        | green        |

DISTRIBUTIONS OF PERCEIVED CHROMATICITIES DERIVED FROM ABOVE  
(C = Chromatic; A = Achromatic)

|                 |      |      |      |
|-----------------|------|------|------|
|                 | 45.5 | C    | C    |
|                 | 46.5 | C    | C    |
| Boundaries,     | 47.5 | C+A  | C    |
| vernier         | 48.5 | A    | C+A  |
| settings        | 49.5 | A+C  | A    |
| of              | 50.5 | C    | A    |
| colour-         | 51.5 | C    | A+?  |
| mixer           | 52.5 | C    | C+?  |
|                 | 53.5 | C    | C    |
|                 | 54.5 | C    | C    |
| Estimated Means |      | 48.5 | 50.0 |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Paula  
DATE: March 2

DISTRIBUTIONS OF OPEN-ENDED RESPONSES (CONTINGENT ON SPECIFIC VIEWING CONDITIONS) TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER HUE-TRANSITION RANGE.

Refer to Data Sheet 2, p. Day No. 1

Serial Status of Test: Pre-experimental

Purpose: To relate characteristics of viewing filters used to colour-mixer characteristics.

Method of Single Stimuli, open-ended judgments.

Viewing Conditions: As shown



| Gaze-Left                                                                                       | Gaze-Right | First Sequence |               | Second Sequence |                |
|-------------------------------------------------------------------------------------------------|------------|----------------|---------------|-----------------|----------------|
|                                                                                                 |            | Gaze-Left      | Gaze-Right    | Gaze-left       | Gaze-Right     |
| 65.0                                                                                            | 25.0       | pinkish grey   | pinkish       | pinkish         | pink           |
| 67.0                                                                                            | 29.0       | pinkish grey   | pinkish grey  | pinkish         | pinkish        |
| 69.0                                                                                            | 30.0       | pinkish grey   | pinkish       | pinkish         | pinkish grey   |
| 70.0                                                                                            | 32.0       | grey           | greyish       | grey            | grey           |
| 72.0                                                                                            | 33.0       | grey           | grey?         | grey            | diffic., pink? |
| 73.0                                                                                            | 35.0       | green-grey     | grey          | greenish        | grey           |
| 74.0                                                                                            | 37.0       | green-grey     | greenish grey | greenish        | more greenish  |
| 75.0                                                                                            | 38.0       | green-grey     | greenish      | greenish        | greenish       |
| DISTRIBUTIONS OF PERCEIVED CHROMATICITIES DERIVED FROM ABOVE<br>(C = Chromatic; A = Achromatic) |            |                |               |                 |                |
|                                                                                                 |            | Gaze-Left      |               | Gaze-Right      |                |
| Max. Red = 0                                                                                    | 29.5       |                |               | C               |                |
|                                                                                                 | 31.0       |                |               | C+A             |                |
|                                                                                                 | 32.5       |                |               | A               |                |
|                                                                                                 | 34.0       |                |               | C+A             |                |
|                                                                                                 | 36.0       |                |               | C               |                |
| Boundaries, vernier settings of colour-mixer                                                    | 37.5       |                |               | C               |                |
|                                                                                                 | 68.0       | C              |               |                 |                |
|                                                                                                 | 69.5       | C+A            |               |                 |                |
|                                                                                                 | 71.0       | A              |               |                 |                |
|                                                                                                 | 72.5       | C+A            |               |                 |                |
| Max. B-G = 100                                                                                  | 73.5       | C              |               |                 |                |
|                                                                                                 | 74.5       | C              |               |                 |                |
| Estimated Means                                                                                 |            | 71.0           |               | 32.5            |                |



CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Paula      DISTRIBUTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON CHANGING  
 DATE: 4 March      VIEWING CONDITIONS, TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER THE  
                          TRANSITION RANGE (culled from raw-data sheets), AND (b) OF DERIVED "ACHROMATICITY"  
 SCORES FOR BOUNDARY VALUES OF SAME SETTINGS; TOGETHER WITH CORRESPONDING STATISTICS SHOWING QUALITY AND  
 DIRECTION OF GAZE-CONTINGENT DIVERGENCES.      (MAXIMUM "ACHROMATICNESS" SCORE = 6 ).

Refer to Data Sheet(s) 3 & 4, p.

Day No. 3

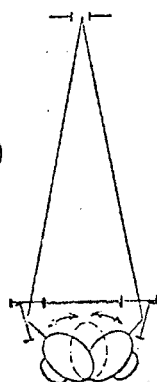
Serial Status of Tests: After first experimental phase

Purpose: (a) Measurement of hue shift through filters, & (b) Measurement of hue-shift after-effect

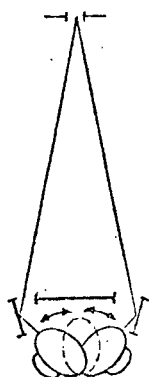
Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: Mirror system

(a)



(b)



|                                   |                                                      | (a)                       |                            | (b)                      |                           |   |      |
|-----------------------------------|------------------------------------------------------|---------------------------|----------------------------|--------------------------|---------------------------|---|------|
|                                   |                                                      | Gaze-Left<br>(Red Filter) | Gaze-Right<br>(B-G Filter) | Gaze-Left<br>(No Filter) | Gaze-Right<br>(No Filter) |   |      |
| (Max. Red Saturation = 0)         |                                                      | R                         | G                          | R                        | G                         | R | G    |
|                                   | 30.0                                                 |                           | 6                          | 0                        | 6                         | 0 | 45.0 |
|                                   | 31.0                                                 |                           | 6                          | 0                        | 6                         | 0 | 46.0 |
|                                   | 32.0                                                 |                           | 4                          | 2                        | 6                         | 0 | 47.0 |
|                                   | 33.0                                                 |                           | 3                          | 3                        | 3                         | 3 | 48.0 |
|                                   | Distributions                                        |                           | 3                          | 5                        | 4                         | 2 | 49.0 |
|                                   | Vernier in                                           |                           | 1                          | 5                        | 3                         | 3 | 50.0 |
|                                   | settings terms                                       |                           | 0                          | 6                        | 1                         | 5 | 51.0 |
|                                   | of of                                                |                           | 0                          | 6                        | 0                         | 6 | 52.0 |
|                                   | colour-mixer raw                                     | 6                         | 0                          | 0                        | 6                         | 0 | 53.0 |
| (Max. B-G Saturation = 100)       | 63.0                                                 | 6                         | 0                          | 0                        | 6                         | 0 | 54.0 |
|                                   | 64.0                                                 | 6                         | 0                          | 0                        | 6                         | 0 | 55.0 |
|                                   | 65.0                                                 | 5                         | 1                          |                          |                           |   |      |
|                                   | 66.0                                                 | 2                         | 4                          |                          |                           |   |      |
|                                   | 67.0                                                 | 1                         | 5                          |                          |                           |   |      |
|                                   | 68.0                                                 | 0                         | 6                          |                          |                           |   |      |
|                                   | 69.0                                                 | 0                         | 6                          |                          |                           |   |      |
|                                   | Distributions                                        |                           | 0                          | 0                        | 0                         | 0 | 45.5 |
|                                   | Boundaries, in                                       |                           | 2                          | 0                        | 0                         | 0 | 46.5 |
|                                   | vernier terms                                        |                           | 5                          | 3                        | 0                         | 0 | 47.5 |
| of derived                        | 33.5                                                 |                           | 4                          | 5                        | 0                         | 0 | 48.5 |
|                                   | 34.5                                                 |                           | 2                          | 5                        | 0                         | 0 | 49.5 |
|                                   | 35.5                                                 |                           | 1                          | 4                        | 0                         | 0 | 50.5 |
|                                   | 36.5                                                 |                           | 0                          | 1                        | 4                         | 0 | 51.5 |
|                                   | of                                                   |                           | 0                          | 0                        | 4                         | 0 | 52.5 |
|                                   | colour-mixer "achromaticness"                        | 63.5                      | 0                          | 0                        | 2                         | 0 | 53.5 |
|                                   | 64.5                                                 | 1                         | 0                          | 0                        | 0                         | 0 | 54.5 |
|                                   | 65.5                                                 | 5                         |                            |                          |                           |   |      |
|                                   | 66.5                                                 | 3                         |                            |                          |                           |   |      |
|                                   | 67.5                                                 | 1                         |                            |                          |                           |   |      |
| scores                            | 68.5                                                 | 0                         |                            |                          |                           |   |      |
|                                   | Sample Sizes                                         | 10                        | 14                         | 18                       | 10                        |   |      |
|                                   | Sample Means                                         | 65.90                     | 33.14                      | 49.22                    | 52.30                     |   |      |
|                                   | Sample SDs                                           | .843                      | 1.151                      | 1.178                    | .789                      |   |      |
|                                   | Medians, Q <sub>2</sub>                              |                           |                            | 49.20                    | 52.25                     |   |      |
|                                   | First Quartiles, Q <sub>1</sub>                      |                           |                            | 48.30                    | 51.63                     |   |      |
|                                   | Third Quartiles, Q <sub>3</sub>                      |                           |                            | 50.13                    | 52.88                     |   |      |
|                                   | Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub> |                           |                            | 1.83                     | 1.25                      |   |      |
|                                   | Mean Interquartile Range, J                          |                           |                            | 1.538                    |                           |   |      |
|                                   | Mean Diffs. in "achr" score units                    |                           |                            | 3.078                    |                           |   |      |
| Mdn. Diffs. in "achr" score units | Mean Differences in J-units                          |                           |                            | 3.050                    |                           |   |      |
|                                   | Mdn. Differences in J-units                          |                           |                            | 2.001                    |                           |   |      |
|                                   | Mean Diff. t value                                   |                           |                            | 1.984                    |                           |   |      |
|                                   | DF                                                   |                           |                            | 7.362                    |                           |   |      |
|                                   | P                                                    |                           |                            | 26                       |                           |   |      |
|                                   | Direction                                            |                           |                            | .000000081               |                           |   |      |
|                                   | Median Diff. Chi-Sq.                                 |                           |                            | 12.6                     |                           |   |      |
|                                   | DF                                                   |                           |                            | 1                        |                           |   |      |
|                                   | P                                                    |                           |                            | .00039                   |                           |   |      |
|                                   | Direction                                            |                           |                            | +                        |                           |   |      |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSTS OF TEST DATA

SUBJECT: Paula DISTRIBUCTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON SPECIFIC  
DATE: 24 March VIEWING CONDITIONS, TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER THE  
TRANSITION RANGE (culled from raw-data sheets), AND (b) OF DERIVED "ACHROMATICNESS"  
SCORES FOR BOUNDARY VALUES OF SAME SETTINGS; TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND  
DIRECTION OF GAZE-CONTINGENT DIVERGENCES. (MAXIMUM "ACHROMATICNESS SCORE = 8 ).

Refer to Data Sheet(s) 5 & 6, p. Day No. 23  
Serial Status of Tests: 3 days after complete training programme  
Purpose: (a) to measure hue-shift after-effect, and (b) to establish nature and extent of laterality bias in viewing system.  
Method of Single Stimuli, Dichotomous (R/G) Responses  
Viewing Conditions: (a) Mirror system, (b) no mirrors, no head-turning



|                                                                       |  | Gaze-Left  |       | Gaze-Right |       | Gaze-Forward (Left Path) |   | Gaze-Forward (Right Path) |   |
|-----------------------------------------------------------------------|--|------------|-------|------------|-------|--------------------------|---|---------------------------|---|
|                                                                       |  | R          | G     | R          | G     | R                        | G | R                         | G |
| (Max. Red Saturation = 0)                                             |  | 43.0       | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
|                                                                       |  | 44.0       | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
|                                                                       |  | 45.0       | 6     | 2          | 8     | 0                        | 8 | 0                         | 8 |
|                                                                       |  | 46.0       | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
| Distributions Vernier in settings of colour-mixer terms of raw scores |  | 47.0       | 6     | 2          | 8     | 0                        | 7 | 1                         | 8 |
|                                                                       |  | 48.0       | 3     | 5          | 8     | 0                        | 4 | 4                         | 8 |
|                                                                       |  | 49.0       | 1     | 7          | 8     | 0                        | 1 | 7                         | 5 |
|                                                                       |  | 50.0       | 0     | 8          | 8     | 0                        | 2 | 6                         | 0 |
|                                                                       |  | 51.0       | 0     | 8          | 8     | 0                        | 0 | 8                         | 1 |
|                                                                       |  | 52.0       | 0     | 8          | 7     | 1                        | 0 | 8                         | 0 |
|                                                                       |  | 53.0       | 0     | 8          | 3     | 5                        | 0 | 8                         | 1 |
|                                                                       |  | 54.0       | 0     | 8          | 4     | 4                        | 0 | 8                         | 0 |
|                                                                       |  | 55.0       | 0     | 8          | 2     | 6                        | 0 | 8                         | 0 |
|                                                                       |  | 56.0       | 0     | 8          | 1     | 7                        | 0 | 8                         | 0 |
| (Max. B-G Saturation = 100)                                           |  | 57.0       | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
|                                                                       |  | 58.0       | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
| Boundaries, vernier settings of colour-mixer                          |  | 43.5       | 0     | 0          | 0     | 0                        | 0 | 0                         | 0 |
|                                                                       |  | 44.5       | 2     | 0          | 0     | 0                        | 0 | 0                         | 0 |
|                                                                       |  | 45.5       | 2     | 0          | 0     | 0                        | 0 | 0                         | 0 |
|                                                                       |  | 46.5       | 2     | 0          | 0     | 1                        | 0 | 0                         | 0 |
|                                                                       |  | 47.5       | 7     | 0          | 0     | 5                        | 0 | 0                         | 0 |
|                                                                       |  | 48.5       | 4     | 0          | 0     | 5                        | 3 | 0                         | 0 |
|                                                                       |  | 49.5       | 1     | 0          | 0     | 3                        | 5 | 0                         | 0 |
|                                                                       |  | 50.5       | 0     | 0          | 0     | 2                        | 1 | 0                         | 0 |
|                                                                       |  | 51.5       | 0     | 1          | 0     | 0                        | 1 | 0                         | 0 |
|                                                                       |  | 52.5       | 0     | 6          | 0     | 0                        | 1 | 0                         | 0 |
| "achromaticness" scores                                               |  | 53.5       | 0     | 7          | 0     | 0                        | 1 | 0                         | 0 |
|                                                                       |  | 54.5       | 0     | 6          | 0     | 0                        | 0 | 0                         | 0 |
|                                                                       |  | 55.5       | 0     | 3          | 0     | 0                        | 0 | 0                         | 0 |
|                                                                       |  | 56.5       | 0     | 1          | 0     | 0                        | 0 | 0                         | 0 |
|                                                                       |  | 57.5       | 0     | 0          | 0     | 0                        | 0 | 0                         | 0 |
| Sample Sizes                                                          |  | 18         | 24    | 16         | 12    |                          |   |                           |   |
| Sample Means                                                          |  | 47.17      | 53.78 | 48.50      | 50.08 |                          |   |                           |   |
| Sample SDs                                                            |  | 1.414      | 1.233 | 1.155      | 1.621 |                          |   |                           |   |
| Medians, Q <sub>2</sub>                                               |  | 47.43      | 53.71 | 48.40      | 49.60 |                          |   |                           |   |
| First Quartiles, Q <sub>1</sub>                                       |  | 46.25      | 52.83 | 47.60      | 49.00 |                          |   |                           |   |
| Third Quartiles, Q <sub>3</sub>                                       |  | 48.13      | 54.67 | 49.33      | 51.00 |                          |   |                           |   |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub>                  |  | 1.875      | 1.833 | 1.730      | 2.000 |                          |   |                           |   |
| Mean Interquartile Range, J                                           |  | 1.854      | 1.867 |            |       |                          |   |                           |   |
| Mean Diff. in "achr" score units                                      |  | 6.610      | 1.580 |            |       |                          |   |                           |   |
| Mdn. Diff. in "achr" score units                                      |  | 6.266      | 1.200 |            |       |                          |   |                           |   |
| Mean Differences in J-units                                           |  | 3.565      | .843  |            |       |                          |   |                           |   |
| Mdn. Differences in J-units                                           |  | 3.390      | .643  |            |       |                          |   |                           |   |
| Mean Diff. t value                                                    |  | 16.18      | 3.02  |            |       |                          |   |                           |   |
| DF                                                                    |  | 40         | 26    |            |       |                          |   |                           |   |
| P                                                                     |  | .000000001 | .0057 |            |       |                          |   |                           |   |
| Direction                                                             |  | +          | +     |            |       |                          |   |                           |   |
| Median Diff. Chi-Sq.                                                  |  | 20.1       | 3.65  |            |       |                          |   |                           |   |
| DF                                                                    |  | 1          | 1     |            |       |                          |   |                           |   |
| P                                                                     |  | .00000012  | .0561 |            |       |                          |   |                           |   |
| Direction                                                             |  | +          | +     |            |       |                          |   |                           |   |

## CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Paula DISTRIBUTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON SPECIFIC VIEWING DATE: 28 March CONDITIONS, TO VERNIER DIAL SETTINGS OF COLOUR-MIXER OVER HUE-TRANSITION RANGE (culled from raw-data sheets); (b) OF O's OWN SETTINGS OF COLOUR-MIXER TO OBTAIN A SUBJECTIVE NEUTRAL POINT, CONTINGENT ON DIFFERENT VIEWING CONDITIONS.

Refer to Data Sheets 7, 8 & 9, p. Day No. 27 Serial Status of Tests: 7 days after complete training programme. Purpose: (a) To measure purely tone-contingent shift, (b) To measure gaze-and-tone-contingent shift without mirrors, and (c) To measure gaze-contingent shift without tones. Methods: (a) Method of Single Stimuli, R/G responses; (b) & (c) Method of Adjustment.

Viewing Conditions: As shown

| Raw Scores |  |  |  | "achromatichness" |  |  |  | Sample Sizes |  |  |  | Sample Means |  |  |  | Sample SDs |  |  |  | Sample Medians |  |  |  | Interquartile Ranges. |  |  |  | Mean Interq. Range, J |  |  |  | Mean Differences |  |  |  | Median Differences |  |  |  | Mean Diffs. in J-units |  |  |  | Mdn. Diffs. in J-units |  |  |  | Mean Diff. t value |  |  |  | Direction |  |  |  | Median Diff. Chi-Sq. |  |  |  | Direction |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  |           |  |  |  |          |  |  |  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 | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  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|  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  | High Tone |  |  |  | Low Tone |  |  |  |  |  |  |  |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

DISTRIBUTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON SPECIFIC VIEWING CONDITIONS, TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER HUE TRANSITION RANGE (culled from raw-data sheets), AND (b) OF DERIVED "ACHROMATICNESS" SCORES FOR BOUNDARY VALUES OF SAME SETTINGS: TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF GAZE-CONTINGENT DIVERGENCES.

SUBJECT: Paula      DATE: 26 April      (MAXIMUM "ACHROMATICNESS SCORE = 8).

Refer to Data Sheet(s) No. 10, p.

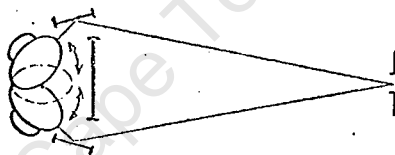
Day No. 55

Serial Status of Tests: 35 days after completion of training programme

Purpose: To establish whether extinction of hue-shift after-effect had taken place

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: Mirror system



|      | Gaze-Left |   | Gaze-Right |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Gaze-Left | Gaze-Right |
|------|-----------|---|------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------|
|      | R         | G | R          | G |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |            |
| 42.0 | 8         | 0 | 8          | 0 | 0:<br>Red saturation = 100<br>max. Red saturation = 100<br>max. B-G saturation = 100<br>"achromaticness" scores                                                                                                                                                                                                                                                                                                                                                          | 0         | 0          |
| 43.0 | 8         | 0 | 8          | 0 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 3         | 1          |
| 44.0 | 8         | 0 | 8          | 0 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 6         | 4          |
| 45.0 | 8         | 0 | 8          | 0 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 7         | 7          |
| 46.0 | 8         | 0 | 8          | 0 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2         | 5          |
| 47.0 | 8         | 0 | 8          | 0 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 2          |
| 48.0 | 5         | 3 | 7          | 1 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 1          |
| 49.0 | 5         | 3 | 5          | 3 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 0          |
| 50.0 | 2         | 6 | 4          | 4 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 0          |
| 51.0 | 0         | 8 | 1          | 7 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |            |
| 52.0 | 0         | 8 | 0          | 8 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |            |
| 53.0 | 0         | 8 | 0          | 8 | Sample Sizes<br>Sample Means<br>Sample SDs<br>Medians, Q <sub>2</sub><br>First Quartiles, Q <sub>1</sub><br>Third Quartiles, Q <sub>3</sub><br>Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub><br>Mean Interquartile Range, J<br>Mean Diffs. in "achr" score units<br>Mdn. Diffs. in "achr" score units<br>Mean Differences in J-units<br>Mdn. Differences in J-units<br>Mean Diff. t value<br>DF<br>P<br>Direction<br>Median Diff. Chi-Sq.<br>DF<br>P<br>Direction | 18        | 22         |
| 54.0 | 0         | 8 | 0          | 8 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 48.94     | 49.80      |
| 55.0 | 0         | 8 | 0          | 8 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .922      | 1.218      |
| 56.0 | 0         | 8 | 0          | 8 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 49.00     | 49.71      |
| 57.0 | 0         | 8 | 0          | 8 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 48.25     | 49.00      |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 49.64     | 50.60      |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1.39      | 1.60       |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1.496     |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .856      |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .714      |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .572      |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .486      |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2.420     |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 36        |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .0207     |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | +         |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1.65      |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1         |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .199      |            |
|      |           |   |            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | +         |            |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Kathryn DISTRIBUCTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON SPECIFIC  
DATE: 17 April VIEWING CONDITIONS, TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER HUE  
TRANSITION RANGE (colled from raw-data sheets), AND (b) OF DERIVED "ACHROMATICNESS"  
SCORES FOR BOUNDARY VALUES OF SAME SETTINGS; TOGETHER WITH CORRESPONDING STATISTICS ONTING SIZE AND  
DIRECTION OF GAZE-CONTINGENT DIVERGENCES. (MAXIMUM "ACHROMATICNESS SCORE = 8 ).

Refer to Data Sheet(s) 1 & 2, p. Day No. 11  
Serial Status of Tests: 3 days after pre-training control sessions  
Purpose: (a) To measure hue-shift after-effect, if any, and (b) To establish nature & extent of  
Method of Single Stimuli, Dichotomous (R/G) Responses laterality bias in viewing system  
Viewing Conditions: (a) mirror system, (b) no mirrors, no head-turning



|                                                                      |               | Gaze-Left |       | Gaze-Right |       | Gaze-Forward (Left Path) |   | Gaze-Forward (Right Path) |   |
|----------------------------------------------------------------------|---------------|-----------|-------|------------|-------|--------------------------|---|---------------------------|---|
|                                                                      |               | R         | G     | R          | G     | R                        | G | R                         | G |
| (Max. Red Saturation = 0)                                            |               | 42.0      | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
|                                                                      |               | 43.0      | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
|                                                                      |               | 44.0      | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
|                                                                      |               | 45.0      | 8     | 0          | 8     | 0                        | 8 | 0                         | 8 |
| Distributions                                                        |               | 46.0      | 7     | 1          | 8     | 0                        | 6 | 2                         | 6 |
| Vernier in                                                           |               | 47.0      | 6     | 2          | 6     | 2                        | 1 | 7                         | 5 |
| settings terms                                                       |               | 48.0      | 5     | 3          | 6     | 2                        | 0 | 8                         | 0 |
| of of                                                                |               | 49.0      | 3     | 5          | 2     | 6                        | 0 | 8                         | 0 |
| colour-mixer raw                                                     |               | 50.0      | 0     | 8          | 1     | 7                        | 0 | 8                         | 0 |
| scores                                                               |               | 51.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
|                                                                      |               | 52.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
|                                                                      |               | 53.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
|                                                                      |               | 54.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
|                                                                      |               | 55.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
| (Max. B-G Saturation = 100)                                          |               | 56.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
|                                                                      |               | 57.0      | 0     | 8          | 0     | 8                        | 0 | 8                         | 0 |
| Boundaries, vernier settings of colour-mixer "achromaticness" scores | Distributions | 44.5      | 0     | 0          |       |                          | 0 |                           | 0 |
|                                                                      | in            | 45.5      | 1     | 0          |       |                          | 2 |                           | 2 |
|                                                                      | terms         | 46.5      | 3     | 2          |       |                          | 7 |                           | 5 |
|                                                                      | of            | 47.5      | 5     | 4          |       |                          | 1 |                           | 5 |
|                                                                      | derived       | 48.5      | 8     | 8          |       |                          | 0 |                           | 0 |
|                                                                      |               | 49.5      | 3     | 3          |       |                          | 0 |                           | 0 |
|                                                                      |               | 50.5      | 0     | 1          |       |                          | 0 |                           | 0 |
|                                                                      |               | 51.5      | 0     | 0          |       |                          | 0 |                           | 0 |
| Sample Sizes                                                         |               | 20        | 18    | 10         | 12    |                          |   |                           |   |
| Sample Means                                                         |               | 47.95     | 48.33 | 46.40      | 46.75 |                          |   |                           |   |
| Sample SDs                                                           |               | 1.099     | 1.043 | .568       | .754  |                          |   |                           |   |
| Medians, Q <sub>2</sub>                                              |               | 48.13     | 48.38 | 46.43      | 46.80 |                          |   |                           |   |
| First Quartiles, Q <sub>1</sub>                                      |               | 47.20     | 47.63 | 46.07      | 46.20 |                          |   |                           |   |
| Third Quartiles, Q <sub>3</sub>                                      |               | 48.75     | 48.94 | 46.79      | 47.40 |                          |   |                           |   |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub>                 |               | 1.55      | 1.31  | .71        | 1.20  |                          |   |                           |   |
| Mean Interquartile Range, J                                          |               | 1.431     |       |            | .957  |                          |   |                           |   |
| Mean Diffs. in "achr" score units                                    |               | .383      |       |            | .350  |                          |   |                           |   |
| Mdn. Diffs. in "achr" score units                                    |               | .250      |       |            | .371  |                          |   |                           |   |
| Mean Differences in J-units                                          |               | .267      |       |            | .361  |                          |   |                           |   |
| Mdn. Differences in J-units                                          |               | .175      |       |            | .388  |                          |   |                           |   |
| Mean Diff. t value                                                   |               | 1.100     |       | 1.209      |       |                          |   |                           |   |
| DF                                                                   |               | 36        |       | 20         |       |                          |   |                           |   |
| P                                                                    |               | .279      |       | .241       |       |                          |   |                           |   |
| Direction                                                            |               | -ve       |       | -ve        |       |                          |   |                           |   |
| Median Diff. Chi-Sq.                                                 |               | .11       |       | .67        |       |                          |   |                           |   |
| DF                                                                   |               | 1         |       | 1          |       |                          |   |                           |   |
| P                                                                    |               | .240      |       | .413       |       |                          |   |                           |   |
| Direction                                                            |               | -ve       |       | -ve        |       |                          |   |                           |   |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Kathryn DISTRIBUTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON SPECIFIC  
 DATE: 29 April VIEWING CONDITIONS, TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER THE  
 TRANSITION RANGE (culled from raw-data sheets), AND (b) OF DERIVED "ACHROMATICNESS"  
 SCORES FOR BOUNDARY VALUES OF SAME SETTINGS; TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND  
 DIRECTION OF GAZE-CONTINGENT DIVERGENCES. (MAXIMUM "ACHROMATICNESS SCORE = 8").

Refer to Data Sheet(s) 3 & 4, p.

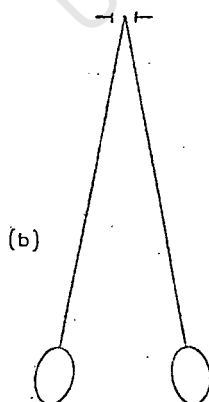
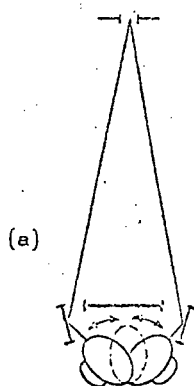
Day No. 23

Serial Status of Tests: 24 hours after first experimental phase

Purpose: (a) To measure hue-shift after-effect, and (b) To establish nature and extent of laterality  
 bias in viewing system.

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: (a) mirror system, (b) no mirrors, no head turning



|                                                            |                  | Gaze-Left |         | Gaze-Right |       | Gaze-Forward<br>(Left Path) |   | Gaze-Forward<br>(Right Path) |   |   |
|------------------------------------------------------------|------------------|-----------|---------|------------|-------|-----------------------------|---|------------------------------|---|---|
|                                                            |                  | R         | G       | R          | G     | R                           | G | R                            | G |   |
| (Max. Red Saturation = 0)                                  |                  | 40.0      | 8       | 0          | 8     | 0                           | 8 | 0                            | 8 | 0 |
|                                                            |                  | 41.0      | 8       | 0          | 8     | 0                           | 8 | 0                            | 8 | 0 |
|                                                            |                  | 42.0      | 8       | 0          | 8     | 0                           | 8 | 0                            | 8 | 0 |
|                                                            |                  | 43.0      | 8       | 0          | 8     | 0                           | 8 | 0                            | 8 | 0 |
|                                                            |                  | 44.0      | 8       | 0          | 7     | 1                           | 8 | 0                            | 8 | 0 |
| Distributions<br>Vernier<br>settings<br>of<br>colour-mixer | in               | 45.0      | 8       | 0          | 7     | 1                           | 7 | 1                            | 6 | 2 |
|                                                            | terms            | 46.0      | 8       | 0          | 6     | 2                           | 7 | 1                            | 5 | 3 |
|                                                            | of               | 47.0      | 5       | 3          | 2     | 6                           | 2 | 6                            | 3 | 5 |
|                                                            | raw              | 48.0      | 6       | 2          | 2     | 6                           | 0 | 8                            | 0 | 8 |
|                                                            | scores           | 49.0      | 4       | 4          | 0     | 8                           | 0 | 8                            | 1 | 7 |
|                                                            |                  | 50.0      | 0       | 8          | 0     | 8                           | 0 | 8                            | 0 | 8 |
|                                                            |                  | 51.0      | 0       | 8          | 0     | 8                           | 0 | 8                            | 0 | 8 |
|                                                            |                  | 52.0      | 0       | 8          | 0     | 8                           | 0 | 8                            | 0 | 8 |
|                                                            |                  | 53.0      | 0       | 8          | 0     | 8                           | 0 | 8                            | 0 | 8 |
|                                                            |                  | 54.0      | 0       | 8          | 0     | 8                           | 0 | 8                            | 0 | 8 |
| (Max. B-G Saturation = 100)                                |                  | 55.0      | 0       | 8          | 0     | 8                           | 0 | 8                            | 0 | 8 |
| Boundaries,<br>vernier<br>settings<br>of<br>colour-mixer   | Distributions    | 42.5      | 0       | 0          | 0     | 0                           | 0 | 0                            | 0 | 0 |
|                                                            | in               | 43.5      | 0       | 1          | 0     | 0                           | 0 | 0                            | 0 | 0 |
|                                                            | terms            | 44.5      | 0       | 2          | 1     | 2                           | 5 | 8                            | 3 | 1 |
|                                                            | of               | 45.5      | 0       | 3          | 8     | 7                           | 8 | 3                            | 1 | 0 |
|                                                            | derived          | 46.5      | 3       | 8          | 7     | 8                           | 3 | 1                            | 0 | 0 |
|                                                            | "achromaticness" | 47.5      | 5       | 4          | 2     | 0                           | 1 | 0                            | 1 | 0 |
|                                                            | scores           | 48.5      | 6       | 2          | 0     | 0                           | 1 | 0                            | 1 | 0 |
|                                                            |                  | 49.5      | 4       | 0          | 0     | 0                           | 1 | 0                            | 1 | 0 |
|                                                            |                  | 50.5      | 0       | 0          | 0     | 0                           | 0 | 0                            | 0 | 0 |
|                                                            |                  |           |         |            |       |                             |   |                              |   |   |
| Sample Sizes                                               |                  |           | 18      | 20         | 12    | 20                          |   |                              |   |   |
| Sample Means                                               |                  |           | 48.11   | 46.40      | 46.33 | 46.45                       |   |                              |   |   |
| Sample SDs                                                 |                  |           | 1.037   | 1.294      | .835  | 1.234                       |   |                              |   |   |
| Medians, Q <sub>2</sub>                                    |                  |           | 48.17   | 46.50      | 46.43 | 46.38                       |   |                              |   |   |
| First Quartiles, Q <sub>1</sub>                            |                  |           | 47.30   | 45.67      | 46.00 | 45.60                       |   |                              |   |   |
| Third Quartiles, Q <sub>3</sub>                            |                  |           | 48.92   | 47.25      | 46.86 | 47.00                       |   |                              |   |   |
| Interquartile Ranges, Q <sub>3</sub> -Q <sub>1</sub>       |                  |           | 1.62    | 1.58       | .85   | 1.40                        |   |                              |   |   |
| Mean Interquartile Range, J                                |                  |           | 1.600   |            | 1.129 |                             |   |                              |   |   |
| Mean Diffs. in "achr" score units                          |                  |           | 1.711   |            | .117  |                             |   |                              |   |   |
| Mdn. Diffs. in "achr" score units                          |                  |           | 1.667   |            | .054  |                             |   |                              |   |   |
| Mean Differences in J-units                                |                  |           | 1.070   |            | .104  |                             |   |                              |   |   |
| Mdn. Differences in J-units                                |                  |           | 1.042   |            | .047  |                             |   |                              |   |   |
| Mean Diff. t value                                         |                  |           | 4.47    |            | .29   |                             |   |                              |   |   |
| DF                                                         |                  |           | 36      |            | 30    |                             |   |                              |   |   |
| P                                                          |                  |           | .000076 |            | .78   |                             |   |                              |   |   |
| Direction                                                  |                  |           | +ve     |            | -ve   |                             |   |                              |   |   |
| Median Diff. Chi-Sq.                                       |                  |           | 5.17    |            | .008  |                             |   |                              |   |   |
| DF                                                         |                  |           | 1       |            | 1     |                             |   |                              |   |   |
| P                                                          |                  |           | .023    |            | .929  |                             |   |                              |   |   |
| Direction                                                  |                  |           | +ve     |            | -ve   |                             |   |                              |   |   |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Kathryn  
 DATE: 24 May  
 DISTRIBUTIONS OF SUBJECT'S OWN SETTINGS OF COLOUR-MIXER TO OBTAIN A SUBJECTIVE NEUTRAL POINT CONTINGENT ON DIFFERENT VIEWING CONDITIONS; TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF GAZE-CONTINGENT DIVERGENCES.

Refer to Data Sheet(s) 5 & 6, p. Day No. 48

Serial Status of Tests: Final post-experimental testing programme

Purpose: To establish nature and extent of gaze-contingent shift (left, right & forward).

Method of Adjustment

Viewing Conditions: As shown

|                                                                                      |           |            |              |           |              |            |
|--------------------------------------------------------------------------------------|-----------|------------|--------------|-----------|--------------|------------|
| (Setting on vernier dial for max. Red saturation = 0; for max. B-G saturation = 100) |           |            |              |           |              |            |
|                                                                                      | Gaze-Left | Gaze-Right | Gaze-Forward | Gaze-Left | Gaze-Forward | Gaze-Right |
| Sample Sizes                                                                         | 20        | 20         | 20           | 20        | 20           | 20         |
| Sample Means                                                                         | 45.79     | 42.58      | 41.73        | 45.79     | 41.73        | 42.58      |
| Sample SDs                                                                           | 1.331     | 1.788      | 1.788        | 1.331     | 1.788        | 1.788      |
| Sample Medians                                                                       | 45.75     | 42.85      | 41.25        | 45.75     | 41.25        | 42.85      |
| Interquartile Ranges (based on SDs)                                                  | 1.799     | 2.401      | 2.403        | 1.799     | 2.403        | 2.401      |
| Mean Interg. Range, J                                                                | 2.100     |            | 2.101        |           | 2.402        |            |
| Mean Differences                                                                     | 3.215     |            | 4.060        |           | .845         |            |
| Median Differences                                                                   | 2.900     |            | 4.500        |           | 1.600        |            |
| Mean Diffs. in J-units                                                               | 1.530     |            | 1.930        |           | .352         |            |
| Mdn. Diffs. in J-units                                                               | 1.380     |            | 2.140        |           | .567         |            |
| Mean Diff. t value                                                                   | 6.450     |            | 8.146        |           | 1.495        |            |
| DF                                                                                   | 38        |            | 38           |           | 38           |            |
| P                                                                                    | .00000014 |            | <.000000001  |           | .14          |            |
| Direction                                                                            | +ve       |            |              |           |              |            |
| Median Diff. Chi-Sq. DF                                                              | 12.1      |            | 28.9         |           | .90          |            |
| P                                                                                    | .0050     |            | .00000008    |           | .34          |            |
| Direction                                                                            | +ve       |            |              |           |              |            |

## CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Kathryn  
 DATE: 25 May  
 DISTRIBUTIONS OF SUBJECT'S OWN SETTINGS OF COLOUR-MIXER TO OBTAIN A SUBJECTIVE NEUTRAL POINT CONTINGENT ON DIFFERENT VIEWING CONDITIONS; TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF GAZE-CONTINGENT DIVERGENCES.

Refer to Data Sheet(s) 7 & 8, p. Day No. 49

Serial Status of Tests: Final Testing Programme

Purpose: (a) To establish nature and extent of gaze-contingent hue shift without tones in ears, and  
 (b) To establish nature and extent of tone-contingent hue shift, without head-movements.

Method of Adjustment

Viewing Conditions: As shown

| (Setting on vernier dial for max. Red saturation = 0; for max. B-G saturation = 100) | Gaze-Left | Gaze-Right | Low tone in left ear | High tone in right ear |  |
|--------------------------------------------------------------------------------------|-----------|------------|----------------------|------------------------|--|
| Sample Sizes                                                                         | 20        | 20         | 20                   | 20                     |  |
| Sample Means                                                                         | 43.67     | 44.72      | 44.08                | 44.95                  |  |
| Sample SDs                                                                           | .828      | 1.093      | .950                 | .742                   |  |
| Sample Medians                                                                       | 43.60     | 44.75      | 43.85                | 45.00                  |  |
| Interquartile Ranges (based on SDs)                                                  | 1.120     | 1.475      | 1.483                | 1.001                  |  |
| Mean Interq. Range, J                                                                | 1.238     |            | 1.242                |                        |  |
| Mean Differences                                                                     | 1.045     |            | .870                 |                        |  |
| Median Differences                                                                   | 1.150     |            | 1.150                |                        |  |
| Mean Diffs. in J-units                                                               | .805      |            | .700                 |                        |  |
| Mdn. Diffs. in J-units                                                               | .884      |            | .925                 |                        |  |
| Mean Diff. t value                                                                   | 3.407     |            | 3.248                |                        |  |
| DF                                                                                   | 38        |            | 38                   |                        |  |
| P                                                                                    | .0016     |            | .0024                |                        |  |
| Direction                                                                            | -ve       |            | -ve                  |                        |  |
| Median Diff. Chi-Sq.                                                                 | 8.1       |            | 2.5                  |                        |  |
| DF                                                                                   | 1         |            | 1                    |                        |  |
| P                                                                                    | .0044     |            | .11                  |                        |  |
| Direction                                                                            | -ve       |            | -ve                  |                        |  |



CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Kathryn  
DATE: 26 May

DISTRICTIONS OF SUBJECT'S OWN SETTINGS OF COLOUR-MIXER TO OBTAIN A SUBJECTIVE NEUTRAL POINT CONTINGENT ON DIFFERENT VIEWING CONDITIONS: TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND DIRECTION OF GAZE-CONTINGENT DIVERGENCES.

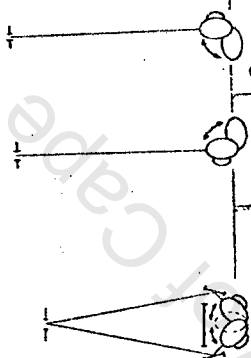
Refer to Data Sheet(s) 9 & 10, p. Day No. 50

Serial Status of Tests: 72 hours after last experimental session.

Purpose: To measure gaze-and-tone-contingent hue shift (a) with mirrors, and (b) without mirrors

Method of Adjustment

Viewing Conditions: As indicated



| (Setting on vernier dial for max. Red saturation = 0; for max. B-G saturation = 100) | Gaze-left Gaze-Right (Mirrors) | Gaze-Left (No Mir.) | Gaze-Right (No Mir.) |
|--------------------------------------------------------------------------------------|--------------------------------|---------------------|----------------------|
| Sample Sizes                                                                         | 20                             | 20                  | 20                   |
| Sample Means                                                                         | 46.71                          | 44.24               | 43.54                |
| Sample SDs                                                                           | .803                           | .921                | 1.287                |
| Sample Medians                                                                       | 46.50                          | 44.20               | 43.50                |
| Interquartile Ranges (based on SDs)                                                  | 1.086                          | 1.243               | 1.739                |
| Mean Interq. Range, J                                                                | 1.165                          | 1.416               | 1.125                |
| Mean Differences                                                                     | 2.47                           | 1.150               | 1.150                |
| Median Differences                                                                   | 2.30                           | .794                | .794                 |
| Mean Diffs. in J-units                                                               | 2.12                           | .812                | .812                 |
| Mdn. Diffs. in J-units                                                               | 1.98                           | 3.310               | 3.310                |
| Mean Diff. t value                                                                   | 8.654                          | 38                  | 38                   |
| Df                                                                                   | 38                             | 10021               | 10021                |
| P                                                                                    | .000000001                     | +                   | +                    |
| Direction                                                                            | +                              | +                   | +                    |
| Median Diff. Chi-Sq.                                                                 | 22.50                          | 2.5                 | 2.5                  |
| Df                                                                                   | 1                              | 1                   | 1                    |
| P                                                                                    | .0000021                       | .11                 | .11                  |
| Direction                                                                            | +                              | +                   | +                    |

CONDITIONING OF GAZE-CONTINGENT HUE RESPONSES: ANALYSIS OF TEST DATA

SUBJECT: Kathryn DISTRIBUCTIONS OF (a) RESPONSES ("RED" OR "GREEN"), CONTINGENT ON SPECIFIC  
 DATE: 29 May VIEWING CONDITIONS, TO VERNIER-DIAL SETTINGS OF COLOUR-MIXER OVER HUE  
 TRANSITION RANGE (culled from raw-data sheets), AND (b) OF DERIVED "ACHROMATICNESS"  
 SCORES FOR BOUNDARY VALUES OF SAME SETTINGS; TOGETHER WITH CORRESPONDING STATISTICS SHOWING SIZE AND  
 DIRECTION OF GAZE-CONTINGENT DIVERGENCES. (MAXIMUM "ACHROMATICNESS SCORE = 8 ).

Refer to Data Sheet(s) 11, p.

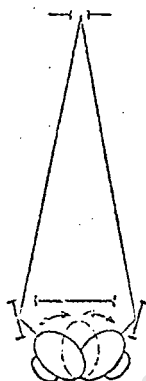
Day No. 53

Serial Status of Tests: Final test, 6 days after last experimental session.

Purpose: To measure gaze-and-tone-contingent hue shift

Method of Single Stimuli, Dichotomous (R/G) Responses

Viewing Conditions: Mirror system



|                                   |      |  | Gaze-Left |       | Gaze-Right |   |   |   |
|-----------------------------------|------|--|-----------|-------|------------|---|---|---|
|                                   |      |  | R         | G     | R          | G | R | G |
| (Max. Red Saturation = 0)         |      |  |           |       |            |   |   |   |
| Distributions                     | 43.0 |  | 8         | 0     | 8          | 0 |   |   |
| Vernier in                        | 44.0 |  | 8         | 0     | 8          | 0 |   |   |
| settings terms                    | 45.0 |  | 8         | 0     | 8          | 0 |   |   |
| of of                             | 46.0 |  | 6         | 2     | 8          | 0 |   |   |
| of of                             | 47.0 |  | 2         | 6     | 2          | 6 |   |   |
| of of                             | 48.0 |  | 2         | 6     | 6          | 2 |   |   |
| colour-mixer raw                  | 49.0 |  | 0         | 8     | 0          | 8 |   |   |
| of scores                         | 50.0 |  | 0         | 8     | 0          | 8 |   |   |
| (Max. B-G Saturation = 100)       |      |  |           |       |            |   |   |   |
| Distributions                     |      |  |           |       |            |   |   |   |
| Boundaries, in                    | 44.5 |  | 0         | 0     |            |   |   |   |
| vernier terms                     | 45.5 |  | 2         | 0     |            |   |   |   |
| settings of                       | 46.5 |  | 8         | 6     |            |   |   |   |
| of of                             | 47.5 |  | 4         | 8     |            |   |   |   |
| of derived                        | 48.5 |  | 2         | 6     |            |   |   |   |
| of derived                        | 49.5 |  | 0         | 0     |            |   |   |   |
| colour-mixer "achromaticness"     |      |  |           |       |            |   |   |   |
| of scores                         |      |  |           |       |            |   |   |   |
| Sample Sizes                      |      |  | 16        | 20    |            |   |   |   |
| Sample Means                      |      |  | 46.88     | 47.50 |            |   |   |   |
| Sample SDs                        |      |  | .885      | .795  |            |   |   |   |
| Medians, $Q_2$                    |      |  | 46.75     | 47.50 |            |   |   |   |
| First Quartiles, $Q_1$            |      |  | 46.25     | 46.03 |            |   |   |   |
| Third Quartiles, $Q_3$            |      |  | 47.50     | 48.17 |            |   |   |   |
| Interquartile Ranges, $Q_3 - Q_1$ |      |  | 1.25      | 1.33  |            |   |   |   |
| Mean Interquartile Range, $J$     |      |  |           | 1.292 |            |   |   |   |
| Mean Diffs. in "achr" score units |      |  |           | .625  |            |   |   |   |
| Mdn. Diffs. in "achr" score units |      |  |           | .760  |            |   |   |   |
| Mean Differences in J-units       |      |  |           | .483  |            |   |   |   |
| Mdn. Differences in J-units       |      |  |           | .589  |            |   |   |   |
| Mean Diff. t value                |      |  |           | 2.23  |            |   |   |   |
| DF                                |      |  |           | 34    |            |   |   |   |
| P                                 |      |  |           | .0325 |            |   |   |   |
| Direction                         |      |  |           | -ve   |            |   |   |   |
| Median Diff. Chi-Sq.              |      |  |           | 1.01  |            |   |   |   |
| DF                                |      |  |           | 1     |            |   |   |   |
| P                                 |      |  |           | .315  |            |   |   |   |
| Direction                         |      |  |           | -ve   |            |   |   |   |

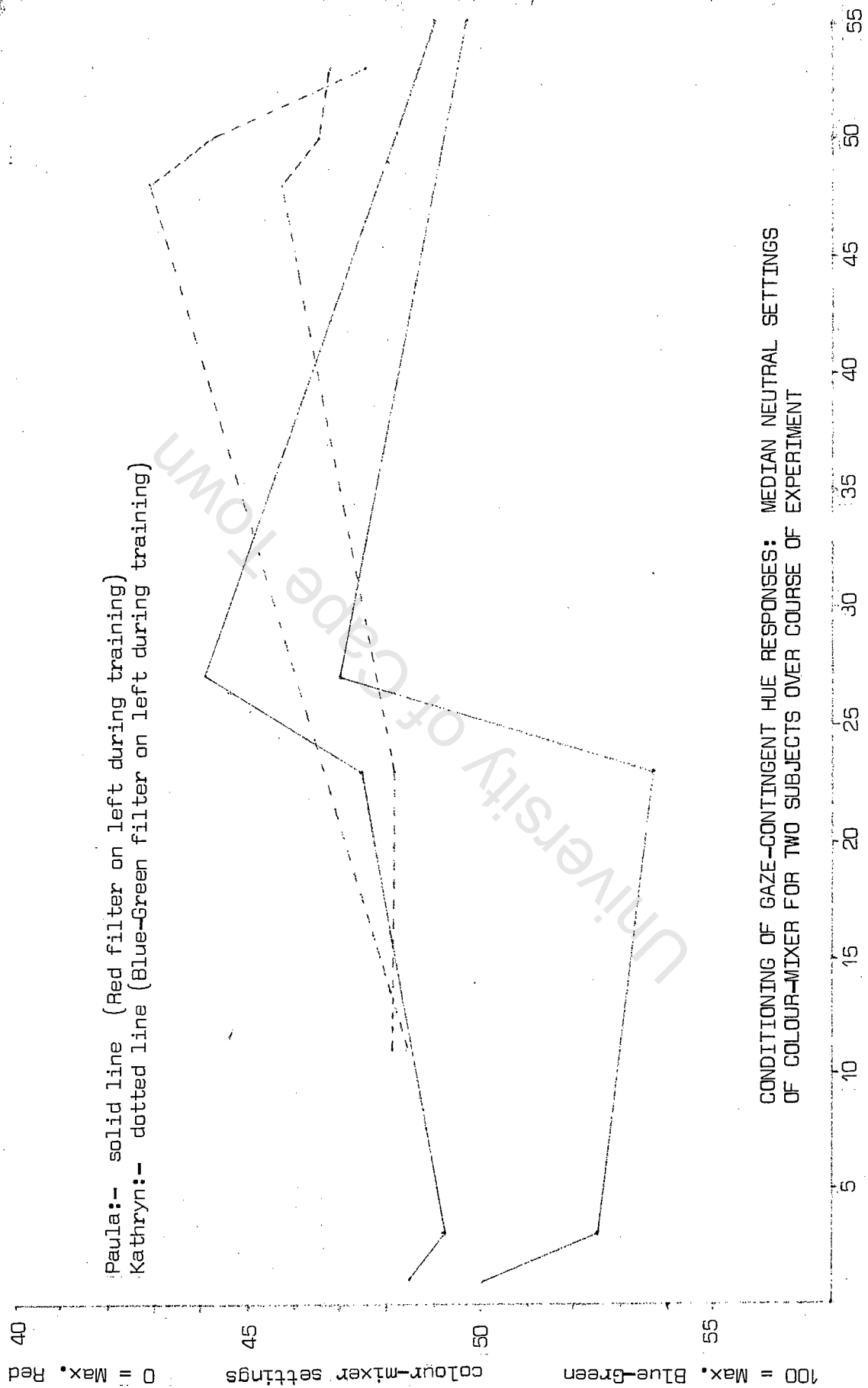
## Appendix 16

GAZE-CONTINGENT CONDITIONING OF HUE-RESPONSES: EXPERIMENTAL DATA  
(Culled from computer printout)

Subject: Kathryn

## PRE-TRAINING CONTROL PHASE

| DATE | DAY NO. | SESSION NO. | NO. OF TRIALS COMPLETED | RANDOMISATION USED | NO. OF 'MATCH ERRORS' | NO. OF 'MISMATCH ERRORS' | TOTAL ERRORS | MEAN REACTION TIME (SECONDS) | MEAN POST-ERROR INSPECTION TIME (SECS.) | TOTAL SESSION TIME (SECONDS) | PERFORMANCE INDEX:<br>MEAN RT X TOTAL ERRORS | MISCELLANEOUS NOTES                                                                                                                                     |
|------|---------|-------------|-------------------------|--------------------|-----------------------|--------------------------|--------------|------------------------------|-----------------------------------------|------------------------------|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7    | 1       | 1           | 72                      | S                  | -                     | -                        | -            | 2.2                          | -                                       | 321                          | -                                            | O instructed to limit her viewing time to specific durations, ranging from 1.5" to 4", as indicated by E at the start of each session.<br><br>.85 hours |
|      |         | 2           | 144                     | S                  | -                     | -                        | -            | 2.0                          | -                                       | 294                          | -                                            |                                                                                                                                                         |
|      |         | 3           | 216                     | S                  | -                     | -                        | -            | 8.6                          | -                                       | 620                          | -                                            |                                                                                                                                                         |
|      |         | 4           | 288                     | S                  | -                     | -                        | -            | 3.8                          | -                                       | 274                          | -                                            |                                                                                                                                                         |
|      |         | 5           | 360                     | S                  | -                     | -                        | -            | 2.6                          | -                                       | 190                          | -                                            |                                                                                                                                                         |
|      |         | 6           | 432                     | S                  | -                     | -                        | -            | 8.5                          | -                                       | 613                          | -                                            |                                                                                                                                                         |
|      |         | 7           | 504                     | S                  | -                     | -                        | -            | 5.8                          | -                                       | 420                          | -                                            |                                                                                                                                                         |
|      |         | 8           | 576                     | S                  | -                     | -                        | -            | 4.6                          | -                                       | 330                          | -                                            |                                                                                                                                                         |
| 10   | 4       | 9           | 648                     | S                  | -                     | -                        | -            | 4.0                          | -                                       | 286                          | -                                            |                                                                                                                                                         |
|      |         | 10          | 720                     | S                  | -                     | -                        | -            | 6.3                          | -                                       | 457                          | -                                            |                                                                                                                                                         |
|      |         | 11          | 792                     | S                  | -                     | -                        | -            | 5.4                          | -                                       | 393                          | -                                            |                                                                                                                                                         |
|      |         | 12          | 864                     | S                  | -                     | -                        | -            | 4.8                          | -                                       | 347                          | -                                            |                                                                                                                                                         |
|      |         | 13          | 936                     | S                  | -                     | -                        | -            | 3.7                          | -                                       | 264                          | -                                            |                                                                                                                                                         |
|      |         | 14          | 1008                    | S                  | -                     | -                        | -            | 4.1                          | -                                       | 294                          | -                                            |                                                                                                                                                         |
|      |         | 15          | 1080                    | S                  | -                     | -                        | -            | 4.8                          | -                                       | 348                          | -                                            |                                                                                                                                                         |
|      |         | 16          | 1152                    | S                  | -                     | -                        | -            | 2.8                          | -                                       | 204                          | -                                            |                                                                                                                                                         |
|      |         | 17          | 1224                    | S                  | -                     | -                        | -            | 2.6                          | -                                       | 260                          | -                                            |                                                                                                                                                         |
|      |         | 18          | 1296                    | S                  | -                     | -                        | -            | 4.4                          | -                                       | 318                          | -                                            |                                                                                                                                                         |
|      |         | 19          | 1368                    | S                  | -                     | -                        | -            | 2.7                          | -                                       | 264                          | -                                            |                                                                                                                                                         |
| 11   | 5       | 20          | 1440                    | S                  | -                     | -                        | -            | 11.4                         | -                                       | 823                          | -                                            | .95 hours<br>Emotional & aesthetic reactions<br>Describe colours to twin sibling                                                                        |
|      |         | 21          | 1512                    | S                  | -                     | -                        | -            | 14.0                         | -                                       | 1010                         | -                                            |                                                                                                                                                         |
|      |         | 22          | 1584                    | S                  | -                     | -                        | -            | 11.8                         | -                                       | 846                          | -                                            |                                                                                                                                                         |
|      |         | 23          | 1656                    | S                  | -                     | -                        | -            | 12.7                         | -                                       | 910                          | -                                            |                                                                                                                                                         |
|      |         | 24          | 1728                    | S                  | -                     | -                        | -            | 10.0                         | -                                       | 720                          | -                                            |                                                                                                                                                         |
|      |         | 25          | 1800                    | S                  | -                     | -                        | -            | 7.8                          | -                                       | 563                          | -                                            |                                                                                                                                                         |
| 12   | 6       | 26          | 1872                    | S                  | -                     | -                        | -            | 7.5                          | -                                       | 540                          | -                                            | Describe colours as novelist would 1.35 hrs<br>Describe colours to blind person                                                                         |
|      |         | 27          | 1944                    | S                  | -                     | -                        | -            | 10.4                         | -                                       | 750                          | -                                            |                                                                                                                                                         |
|      |         | 28          | 2016                    | S                  | -                     | -                        | -            | 8.7                          | -                                       | 623                          | -                                            |                                                                                                                                                         |
|      |         | 29          | 2088                    | S                  | -                     | -                        | -            | 6.7                          | -                                       | 483                          | -                                            |                                                                                                                                                         |
|      |         | 30          | 2160                    | S                  | -                     | -                        | -            | 17.9                         | -                                       | 1286                         | -                                            |                                                                                                                                                         |
|      |         | 31          | 2232                    | S                  | -                     | -                        | -            | 5.5                          | -                                       | 393                          | -                                            |                                                                                                                                                         |
| 14   | 7       | 32          | 2304                    | S                  | -                     | -                        | -            | 19.6                         | -                                       | 1413                         | -                                            | 1.13 hours<br>Describe colours in terms of R, Y, G & B, quantified to add up to 10<br>1.32 hours<br>Total: 5.61 hrs                                     |
|      |         | 33          | 2376                    | S                  | -                     | -                        | -            | 20.7                         | -                                       | 1490                         | -                                            |                                                                                                                                                         |
|      |         | 34          | 2448                    | S                  | -                     | -                        | -            | 22.0                         | -                                       | 1586                         | -                                            |                                                                                                                                                         |
|      |         | 35          | 2520                    | S                  | -                     | -                        | -            | 3.7                          | -                                       | 265                          | -                                            |                                                                                                                                                         |



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In addition to serving as a general index, the following pages provide definitions of technical terms, especially colour terms as used by colour-scientists. (These definitions may sometimes be in conflict with the conceptual framework presented in this thesis. See, for example, the definition of "hue").

The main source has been the volume entitled, "The Science of Color", edited by the Committee on Colorimetry of the Optical Society of America (abbrev. OSA). Another source has been "A Comprehensive Dictionary of Psychological and Psychoanalytical Terms", by H.B. English and A.C. English (abbrev. E & E).

In the case of terms used with a special connotation in this thesis, a definition has been provided when it seemed necessary. In other cases the reader should experience little difficulty in establishing the usage from the references provided to the text itself.

- Abramovitz, A., 30, 63, 92, 228, 370, 372.
- achromatic colour: colour that does not elicit hue; colour that is neutral as to hue; perceived achromaticity (OSA), 87.
- achromaticity, 113.
- achromaticness: absence of chromaticness (q.v.); perceived achromaticity, 81, 114, 115, 116.
- "achromaticness scores", 120.
- achromatopsia: vision in which discrimination of hue and saturation is completely lacking; inability to make any chromaticness discriminations (OSA), 35.
- "acoustic space", 238.
- adaptation (vision): change of sensitivity of eye to meet the needs of vision (OSA), 226.
- adaptation, criterion of performance (gaze-contingent study), 188, 189, 224-5.
- adaptation of periphery of retina, long-term, 166.
- agoraphobia, 141.
- Alexander, S., 30, 112.
- alloretinal afferents: non-retinal elements of the compound afferent input, to which colour responses (motor and/or verbal) can become conditioned and which thereby become organized into the functional equivalence class of the relevant colour, 4, 8, 227, 235.
- analytic attitude: interest in nature of visual stimulus rather than in stimulus as object (OSA). Cp. drive, role of (q.v.), 215, 216.
- anthropologists and colour. See cultural determinants of colour responses.
- aperture mode of appearance of colours: nonlocated mode, by which colour is perceived when divorced as completely as possible from all of the spatial and temporal attributes of other modes of appearance (OSA), 26, 175.
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- "autosuggestion", 68.
- "awareness centres" of CNS, 20.
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- bi-modality stimulation, 47.
- Binet-Simon Scale of Intelligence, 33.
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 cataract-operated patients, 18, 172.  
 Chapanis, A., 237, 371, 374.  
 chroma: portion of Munsell notation that corresponds to saturation (OSA).  
 chromaesthesia: colour-tone synaesthesia, 44, 46, 69.  
 chromaesthesia, musical, 41.  
 chromatic aberration: imperfection of an image produced by variations of index of refraction of elements of an optical system (OSA), 174.  
 chromatic colours: colours eliciting hue (OSA).  
 chromatic deprivation, 36. See also goggles, hue-attenuating.  
 chromaticity: composite of dominant wavelength and purity (OSA), 35, 113, 1  
 chromaticity co-ordinates: proportions of standard components required for colour match, used as ordinate and abscissa to represent colour in chromaticity diagram (OSA), 81, 87.  
 chromaticness: hue and saturation, taken together, expressive of the quality of colour sensation as distinguished from its intensity (OSA), 15, 35, 85, 113.  
 "chromaticness scores", 113.  
 chromatoscope: type of colour-mixer, 57.  
 C.I.E. chromaticity diagram: formed by plotting C.I.E. (Commission Internationale de l'Eclairage) chromaticity co-ordinates (OSA), 246a.  
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 colour and pupillary dilation, 46.  
 colour and wavelength. See wave-composition.  
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 colour constancy: substantial invariance of object-colour perceptions in the presence of changes in illumination or other viewing conditions (OSA), 7, 8, 26, 30, 31, 33, 34, 36, 37, 61, 142, 156, 171, 172, 232, 239.  
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colour-mixer, 57, 81, 178, 185, 186, 187, 246f.  
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colour response, 153.  
colour science: knowledge concerning the production of colour stimuli and the visual perception of them (OSA), 9, 50, 237, 241, 242  
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colour "stimulus", 20.  
colour temperature: temperature of complete radiator having same chromaticity as the source in question (OSA), 81.  
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colour vision theory: See theory of colour vision.  
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comparative colour categorizing. See cultural determinants of colour responses.  
complementary colours: pairs of samples of light that have complementary chromaticities and also the proper relative amounts of luminous flux to produce an achromatic mixture (OSA), 37, 50, 85.  
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 density, optical. See optical density.  
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 dichotic stimulation: stimulation affecting the two ears differently (E & E 77).  
 difference threshold for chromaticity: chromaticity difference of just-noticeably different colours having equal luminance (OSA).  
 differential colour threshold: amount of difference between two colours that is required for perceptibility in a prescribed proportion of many independent trials (OSA).  
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 dominant wavelength: wavelength of spectrally pure energy that if mixed with white light would match a colour (OSA).  
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     attributes except size and shape are recognized (OSA),  
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