A study to investigate whether consistent cognitive functioning is characteristic of the child's performance on the Piagetean tests of number, space and time.

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GLOSSARY.

The following is a brief glossary of the Piagetean terms used in the present study, and which, on account of their unfamiliarity, may present some difficulty.

1. Accommodation

A transformation by environmental stimuli in the existing behaviour structures of the child. This modification increases the child's capacity to react adequately to still further environmental stimuli, and for this reason the scope of the child's behaviour is widened with each new accommodation.

2. Assimilation.

In order that accommodation can come about, it is necessary that environmental stimuli are themselves transformed via the appropriate sense organs and nerve fibres. This is the process of assimilation.

3. Centration.

This implies a tendency in the child to fixate her attention on one aspect of the stimulus configuration, this aspect being the purely perceptual quality of the situation. As a result of this perceptual overdependence, which is characteristic of the pre-operational child, the object so fixated is distorted and for this reason is not regarded as an entity with overall properties of its' own.

4. Classification.

The ability to group objects in one and the same class on the basis of a property common to all.

5. Egocentrism

This term marks a strong tendency in the child towards centration. This aspect is not regarded as an entity with qualities of its own, but as something intrinsic to the child himself. The point of view which he adopts towards the situation, he therefore regards as the exclusive one. Hence the distortion of the perceptual field which results.

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6. Equilibrium

A state in the child during which assimilation and accommodation are in perfect balance. This means that environmental stimuli are adequately transformed via the appropriate sense organs and that assimilated stimuli can readily be accommodated by the already existing behaviour structures.

7. Euclidean Relations

The euclidean relationship of various objects located in space, refers to that relationship existing between one aspect and the next. Whereas topological relationships express the relationships between properties intrinsic to one and the same object, euclidean relationships imply an adequate co-ordination between various independent aspects in the same spatial field.

8. Grouping

This word is a collective term to describe a number of co-ordinated operations which contribute to the child's conceptualization in a particular field of cognition.

9. Operation

A physical action which has become internalized as an image and is co-ordinated with other internalized actions. Whereas the child's physical action is limited to the confines of the situation, once this action is represented mentally, the situation can readily be manipulated, and hence the child's thought processes become mobile and flexible.

10. Reversibility

An ability to deduce from the final conclusion, the nature of the original premise, and vice versa. Hence mobility of thought.

11. Seriation

The ability to differentiate one object, or class of objects, from another object, or class of objects, on the basis of that property, whereby they may be discriminated, e.g. size, weight, colour etc.

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12. Topological Relationships

Topological relations of an object located in space, refer to relationships of openness, closure, proximity and separation; those relationships which are built up between various parts constituting one and the same figure. Topological relations therefore relate purely to the internal character of a particular object in space.

1. INTRODUCTION

(a) Statement of the Problem

The developmental psychology of Jean Piaget has, within recent years, been primarily concerned with an application of his general theory of cognitive development to a wide area of cognitive functioning. Piaget has considered the most obvious facets of man's everyday thinking and reasoning and proposed to show that a rich developmental history underlies even his most common concepts. In so doing, Piaget has broached a topic which is so novel and compelling, and one which lays open such a vast field of research, that one cannot fail to recognize his contribution to psychology in formulating these suggestions alone.

Piaget's major theoretical contention is that cognition develops in clear-cut sequential stages alike for every child. Although Piaget has never defined his meaning of "stage", it may be deduced from his prolific writings that he implies by this term a specific developmental "level" in the child during which his cognitive functioning in all areas takes a characteristic form, and can be differentiated, according to clearly defined criteria, from his functioning at another developmental "level". Intelligence, then, is a unitary or global capacity which determines, within small limits, consistent cognitive functioning within all areas at any specific time. While Piaget has formulated his theory at great length, and shown on the basis of his research, that specific levels or stages of which he talks emerge broadly at certain ages, he has as yet not introduced an adequate experimental procedure to determine whether a child functions consistently in any one area of cognition, and secondly, whether his level of cognitive functioning remains significantly stable in a number of different areas, at any one period of development. This would implicitly follow from his theory of a homogeneous intelligence and

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might perhaps be considered as one of the most fundamental conditions to be substantiated in proof of Piaget's contentions. It is these two specific questions that we propose to answer in the present study. Three Piagetean content areas, those of number, space and time, have been considered for this purpose.

A representative sample of Piagetean tests has been selected from each of these areas, in an attempt to note whether each child in a sample of fifty-eight subjects, ranging from six to nine years, displays a consistent level of cognitive functioning within each of the three content areas, and between one area and another. A positive finding in this direction would point to the relevance of a theory of critical periods of development at the human level and may have important implications not only for psychology, but for education as well. Particularly in the latter case, if our contentions find support, there may be suggestions for a vast re-organization of educational programmes.

(b) Survey and Appraisal of Related Literature

The history of psychology shows that the development of ideas did not follow a uniform trend. In the contrary, fresh interpretations were constantly rendered and it stands to reason that the emergence of such conceptions brought often a strong conflict with previously accepted opinions. This is actually a healthy and essential development and it is perhaps this feature of living progress which has given to this science the impetus to its growth and vigour. The antithetical issues have been many and varied, but frequently at the core of the arguments the nature-nurture question can be found. On the one hand men claimed that learning and experience were the most important determinants of behaviour. On the other, it was considered that man's inherited potential was prepotent in moulding his development. Both these extreme viewpoints gave rise to powerful

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exponents, a fact which clearly emerges from even a brief survey of psychological history.

The opening of the 20th century saw the upsurge of a new school of thought, Behaviourism. This school was in many respects a reaction against introspectionism. The Behaviourists, with J.B. Watson as their chief exponent, stressed the importance of studying behaviour per se and at face value. Terms such as "consciousness", "mental states", "mind" and "imagery", they considered as vague or devoid of meaning. While the Behaviourists later made provision in their theory for emotions or after-images, the "Tabula rasa" theory was widely accepted by the early followers of the school. This theory implied that the child's behaviour was determined by environmental stimuli which, so to speak, impinged on the organism and moulded his behaviour, while innate determinants were of significantly less importance.

The Behaviourists were soon faced with powerful opposition. With W. McDougall as their chief spokesman, the Purposive school claimed that all behaviour was directed towards a goal and that it was pre-determined by instincts or"psychophysical dispositions" which determined the emotional quality which an aspect or situation signified for the child, and hence the motor response which the situation evoked. Man's behaviour was thus predominantly determined by his genic constitution. Already in 1908 in his book "Introduction to Social Psychology" McDougall stated these ideas with much conviction, even going so far as to enumerate those major instincts which determine man's primitive desires and purposes. Both these schools of thought gave rise to various offshoots in support of either one or the other extreme viewpoint, and engaged in feuds which in many respects were entirely fruitless.

What stands out strikingly in these arguments is the complete disregard on the part of either opponent to take his position midway between these extreme paths. One gets the impression that the

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field of psychology was stringently divided in two, and while some rather timidly approached the central position, few in fact saw that the essential site was here, that this was the core of a true psychology, and that only here a challenge would be fruitful. To this rather stagnant state of affairs, the writing of Sigmund Freud brought something of a revelation. Regardless of whether his interpretations are correct or not, Freud's theory made clear that behaviour was the result of an interaction between environmental forces and the child's inherited potential. The attempts which were made to ascertain whether behaviour was determined from within or without or even to what extent either of these constituents operated, he regarded as entirely fruitless. It was only by looking at man's behaviour from two vantage points, he realized, that a thorough and undistorted understanding of behaviour could be gained. This was perhaps Freud's most important contribution to psychology, for his theory had the effect of turning man's thinking away from the rigid extremist viewpoints, of inducing him to realize how completely fruitless and static a one-sided dissemination could be.

The developmental psychology of Jean Piaget, which is the topic of the present thesis, must now be considered. Where, one may ask, does the work of Piaget fit into the framework discussed above? This is an important question, for in determining this position, Piaget's theory will be placed in correct perspective. Piaget has never affiliated himself to any particular school, but the layout of his theory strongly suggests an interactionist point of view. Confining his interests strictly to the development of the child's cognition, Piaget believes that the course of the child's development is potently determined by the individual's inherited potential, but unless the environment is sufficiently stimulating, and an adequate interaction takes place between the

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organism and this environment, there is a lag in the child's development and he shows retardation in relation to the norm. This contention certainly marks Piaget as an interactionist, but there are two reservations which must be made before Piaget's position can be ultimately defined.

While Piaget considers the nature of the environment as an important factor in the child's development, there seems little doubt from his work that he implies only the physical environment. The failure to consider the major part of the child's environment as constituted by other individuals, is a serious omission, as shall be discussed later, and has resulted in a theory which provides for the child's cognitive development entirely divorced from affective influences.

In the second instance, one has the impression that in the practical application of his theory, Piaget is inclined to place more emphasis on the innate determinants of the child's behaviour. This stems from his most important contention that cognition develops in clear-cut sequential stages, which are alike for every child and determined by sporadic maturation of the brain structures. This Piaget considers as a general rule of development and one that is widely applicable to children of every culture. The generality of this developmental pattern is attributable to certain biological determinants, common to every human, and this constitutes the predeterministic element of Piaget's theory. Individual differences certainly exist between children, but only insofar as the specific stages do not appear at identical ages in the life of every child. In this connection, interaction between the organism and environment is predominantly important. If the child's environment and particularly his physical environment is poorly endowed, the developing child is not adequately stimulated and the stages will

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follow each other at greater intervals. However, within broad limits, Piaget has succeeded in confining these stages to particular age levels.

Having defined his position within the psychological field, it is necessary at this point to follow Piaget's own history more thoroughly in an attempt to place his theory of cognitive development in correct perspective, and relate its inception to areas of study which are not strictly psychological in nature.

Piaget opened an impressive career with a study of biology and zoology, and already in 1912, when he was only sixteen, he published a number of important papers on Molluscs. In 1918 the degree of Doctor of Science was conferred on him from the Neuchatel University for similar work in this field, and until 1929 Piaget continued to make important contributions to zoology. In 1920, however, Piaget made his first break from his previous zoological studies, when he undertook an offer to standardize Burt's reasoning tests on a group of Parisian children. In the course of conducting his work, he became particularly interested in the reasoning processes of children in the sample. This provided the first stepping stone to his study of developmental epistemology. It was during this period also that he was appointed head of the Research Work Department at the Institut J.J. Rousseau, and at the same time lectured at the Geneva and Neuchatel Universities. In 1929 Piaget turned his attention entirely from biology and settled down to a study of psychology and sociology. He lectured on these subjects both at Geneva and Luassane. At this time he also conducted careful investigations on his own infants, studying step by step the development of their cognitive activity, systematically recording their behaviour and laying down the foundations for his general theory of intellectual development. Piaget's entire interest was devoted to Psychology when

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he was appointed Professor of Psychology at the Sorbonne in Paris in 1936. During the follow- creative years, Piaget devoted himself predominantly to a practical application of his theoretical tenets to specific areas of cognitive functioning. Thus he studied and published books on number, quantity, movement, velocity, time and space, while continuing still to make further theoretical deductions. In particular he devoted much time to the study of biological structures underlying intelligence. Today Piaget still holds the chair at both the Sorbonne and University of Geneva, and in addition is the head of the International Centre of Genetic Epistemology, created in Geneva in 1955.

There are several salient points in Piaget's theory of developmental epistemology at the human level, which relate directly to his earlier acquaintance with biology and zoology. The following aspects of Piaget's theory of cognitive developments are perhaps the most obvious links with his earlier affiliations :- Intellect develops in clear-cut stages, corresponding to sporadic maturation of underlying brain structures. The structures which underlie cognitive development are hierarchically organized and finally, the intelligent behaviour which they subserve is always adaptive in nature.

There is little doubt that Piaget's study of biology turned his attention to the structural aspects of the organism, particularly the organization of its nervous system and its motor and sensory organs. It is generally agreed that at the very primitive level of reflex organization, in which the action of sensory and motor organs is predominant, organization appears to take the form of a hierarchy. On the basis of the earliest and most primitive nervous structures, new structures develop and these in turn serve as a foundation upon which further structures evolve. It is this complete model which Piaget

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has adopted to explain structural organization at the human level. Thus, according to Piaget, the most primitive or earliest structures underlying intelligence serve as the basis for later structures and hence more complex behaviour. From this it follows that cognitive development must follow the identical course in every child, for until the earlier structures have evolved, there is no basis for more complex ones.

The theory of clear-cut stages of development is also an outgrowth of his early training in biology and zoology. Piaget's study of the structural organization of nervous systems in creatures low on the phylogenetic scale, such as members of the molluscoid family, no doubt centred his attention on the sporadicity with which such central structures mature. The development of new structures in these creatures he correlated with the emergence of new behaviour, an observation which readily supported his opinion that a like phenomenon exists at the human level.

He therefore hypothesized that three stages were clearly discernible in the child's cognitive development, dependent on the sporadic maturation of underlying brain structures.

We come now to the third link between Piaget's theory of cognitive development and his early zoological studies. This relates to Piaget's major premise that intelligence is adaptation or the child's ability to integrate successfully any one experience with his present store of knowledge. Already in 1929, Piaget was specializing in the study of the powers of adaptation in the Limnea Stagnalis, and there is little doubt that he saw the possibility for similar characteristics in intelligent behaviour at the human level. Thus one finds such statements in his writing as the following : "A double interest in the problems of variation and adaptation caused us to dream of building a biological epistemology

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based exclusively on the notion of development" (Paiget 1958). This statement is of particular interest for it shows the direct link between Piaget's earlier studies and his present investigation of intellectual evolution in the child. It is clear, then, that Piaget's treatment of the structural organization of the human central nervous system is to some extent based on a generalization he has made from a study of the central organization and development of creatures low down in the phylogenetic scale.

There are, however, a number of very obvious difficulties which must arise from this treatment of intellectual development at the human level. While it appears to be perfectly adequate to relate the behaviour of organisms low on the phylogenetic scale directly to the biological organization of their brain structures, one hesitates in drawing such a direct or immediate correspondence between this biological organization and the behaviour of the child. One may well ask whether clear-cut stages in cognitive development will be found at the human level where learning dominates so much of man's behaviour, and where, as a result of the evolvement of the hypothalamus and cortex, behaviour is frequently coloured by emotions. Is it possible to draw a direct correspondence between the pattern of structural organization in the child, and the pattern of his behaviour, as readily as one can make this analogy in creatures whose behaviour is almost instinctive and independent of environmental and perhaps especially of interpersonal forces? To frame the question in this way is perhaps to overlook the important condition which Piaget stipulates is fundamental to adequate intellectual development at the human level. This is the importance of a stimulating environment for the developing child so that adequate interaction can take place between the organism and environ-

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ment, a condition which, as shall be shown later, is fundamental to the development of new brain structures. Yet Piaget's theory holds, that irrespective of the diversified environmental conditions which individual children experience, the biological structures underlying intelligence will in themselves still be of sufficient consequence to determine the course of development in fixed and clear-cut stages. The problem which thus emerges is the following: What other evidence is there, that cognition develops in stages, besides the purely biological studies which predict a development in critical stages exclusively on the basis of the structural organization of the nervous system? Is there evidence which relates less to purely structural or organic considerations, but rather to more clearly behavioural aspects? It appears that an outstanding link has, in fact, been provided between Piaget's studies in biology and zoology and his contentions about developmental epistemology. This is the extensive bulk of work which has been conducted in recent years by ethnologists, the important implications of which must be discussed.

Piaget himself has certainly never considered his work in relation to ethnological findings, but we regard his work of intellectual development at the human level as having a very important association with studies in animal development. The specific issues with which the ethnologists have concerned themselves in recent years shall not be discussed here. Of greater relevance to Piaget's work, is a general principle which has gradually been formulated over the years of study in this field. Research has shown that as the phylogenetic scale is ascended, the role of the innate determinants of behaviour appears to diminish, while the interaction between the environment and the organism's inherited potential becomes predominantly more important

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in determining the organism's behaviour. Thus the very close relationship between behaviour and structural organization, which is evident in the lowest species of the animal kingdom, becomes progressively more difficult to determine.

In addition it seems to follow from ethnological studies that the lower the organism on the phylogenetic scale and the more clearly it's behaviour is determined by it's innate potentiality, the easier it is to define clear-cut stages of development, alike for every member of the species. On the other hand, the greater the interaction between the inherited potential of the organism and its experiences, the more concealed these stages of development. Looked at from this point of view, it becomes clear that ethnology serves as an important link between Piaget's early biological conceptions and his present research on developmental epistemology. The biological studies of Piaget showed him that the developing central nervous system of an organism matures sporadically, and from this it followed that the behaviour which these structures underlay, would emerge with equal sporadicity. This certainly supported a theory of development in stages. The ethnologists, working at a different level, which could perhaps be defined as clearly more behavioural, concluded likewise that the behaviour of the developing organism does emerge in certain fixed stages, but that these stages become progressively more difficult to define as one climbs the evolutionary scale. At the human level, therefore, since the environment is so complex and must necessarily vary from one individual to the next, it is conceivable that any clear-cut stages of development may be readily camouflaged. But Piaget's work gives us an interesting challenge. Is it so, that the developing organisms, though each subjected to different

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and variable environments, are at any one point of maturation so limited in the degree to which they might react to the environment or be reacted upon, that it is still possible to discern certain stages of development in all these children, provided one has the suitable techniques for doing so. Is it in fact so that the complexity and variability of man's behaviour has too readily been accepted, that it has been regarded too superficially, and that in fact stages of development do exist if his behaviour is analysed more carefully.

Piaget, as many others too, has staked his claims that such stages do in fact exist, and that they are particularly characteristic of the child's cognitive development. It now remains for us to consider exactly what such stages entail for Paiget, the techniques and methodology which he has employed, the general trend of his findings, and the support for or against a theory of stages emerging from the work of other noted theorists in the field of epistemology.

11. PIAGET'S THEORY OF INTELLIGENCE

In order to comprehend Piaget's theory of stages of development, as well as to understand the nature of the present hypothesis, it is necessary to define intelligence within the Piagetean framework.

According to Piaget, intelligence is by its very nature, both logical and biological. The biological counterpart of intelligence is constituted by those structures in the brain which mature in fixed stages, and through which intelligence may function. The logical characteristics of intelligence, on the other hand, are to be found in both its function and content. It is characteristic of the child who can conceptualize adequately, that he can

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employ certain logical premises in relevant situations, and it is this behaviour which Piaget defines as "intelligent". Piaget is not concerned with logic per se, but he sees in logical thinking the model for intelligent behaviour. "Perhaps one could say that Piaget uses logic in a way analogous to the American use of theories of motivation (either reinforcement theory or psychodynamics) as an external frame of reference for study of the learning processes" (Inhelder & Piaget 1958. p.1X) In addition, intelligent behaviour is always operational. It is the concept of "operation" which is perhaps the most fundamental to an adequate understanding of Piaget's theory of intelligence. An operation has been defined by Piaget as an internalized action. Whereas a child who performs an action is limited to the confines of the situation, the child who internalizes the action or represents it mentally, is able to manipulate the situation beyond the bounds of physical possibility. Once deductions can be made on the basis of internalized actions, thoughts become mobile and flexible, or characterized by what Piaget has called "reversibility". These internalized actions do not exist independently or in isolation but cohere to form well-structured systems and it is this co-ordinated system which constitutes an operation.

Also fundamental to an understanding of Piaget's theory of cognitive development are the concepts of assimilation accommodation, for it is upon the functioning of these that intellectual development is immediately dependent. In simplest terms "assimilation" implies the brain's capacity to react to stimuli via appropriate sense organs, while accommodation refers to the sparking off of a new nerve fibres in the brain by assimilated

stimuli ...

stimuli. These assimilated stimuli change somewhat the structures to which they are accommodated and it is this modification which increases the child's capacity to react adequately to still further environmental stimuli. Thus with every assimilation and accommodation, the child's intellectual capacity is widened. It follows also that if the child's environment is richly endowed, he will through repeated assimilations and accommodations acquire those brain structures which make further accommodations possible. When the child's environment is poor, however, the existing brain structures will not be modified as readily and the child's development will be retarded. When the brain structures can readily accommodate what is being assimilated, Piaget refers to this state as the state of equilibrium or adaptation, and this implies that the organism and environment interact in such a way that the environmental demands on the organism are not too great, while at the same time the response is adequate to the situation. Thus in defining intelligence Piaget (1950 p.9) has said the following :-

> "Intelligence whose logical operations constitute a mobile and at the same time permanent equilibrium between universe and thought is an extension and perfection of all adaptive processes".

At another point (Ibid. p.7) Piaget has stated the following :-

> "Intelligence is thus only a generic term to indicate superior forms of organization or equilibrium of cognitive structurings".

It is interesting to note that a very close analogy exists between Piaget's concept of

adaptation through assimilation and accomodation and Hebb's theory of phase sequences and cell assemblies. Thus Hebb has said that the basic structures underlying intelligent behaviour are cell assemblies which, through a process closely affiliated to assimilation and accommodation, develop into larger schemas or phase sequences, the structures of more complex behaviour.

While assimilation and accommodation are fundamental to the development of intelligence, this does not constitute the complete picture according to Piaget. Even if the child's environment is richly endowed, there is a limit at any one period in the child's life to which assimilation and accommodation can take place. This limit is set by innate or inherited determinants which account for the degree of maturation in the brain structures at any developmental level in the child's life. If adequate maturation has not occurred, assimilation and accommodation are confined to operate only within certain limits. It is on the basis of these theoretical tenets that Piaget has constructed a theory of development in fixed and clear-cut stages, the sequence of which is alike for every child.

We must now turn to a discussion of these stages and place particular emphasis on the concrete operational stage which is of immediate relevance to the present project.

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Piaget defines three major stages of cognitive development, the sensori-motor stage, the stage of concrete operations and the stage of formal operations. These stages always appear in this sequence in the life of every child.

During the first or sensori-motor period Piaget defines six substages, the exact nature of which it is not relevant to discuss here.

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Within the first two years of life, however, there are three major trends which characterize the child's cognitive development. The most primitive cognitive functioning takes the form of reflex actions. This is followed by a period of habit formation and finally there emerges intellectual behaviour of primitive nature. The primary structures underlying reflex action evolve through a process of assimilation and accommodation into schemata of a higher order and these schemata are fundamental to the formation of habits. These habits are constituted by internalized actions, but since there is no co-ordination between structures underlying habit formation, there can be no reversibility or mobility of thought characteristic of intelligent behaviour. Towards the end of the sensori-motor period, however, intelligent behaviour does emerge, determined by the first primitive co-ordination of schemata.

The rigid thought processes characteristic of the habit make way for greater flexibility. For the first time the child can make correct generalizations and differentiations. He will, for example, smile at the sight of his mother's face and cry when a mask is held over his pram. His behaviour also becomes increasingly more adaptive and for the first time he comes to differentiate the means towards a particular end. During the sensori-motor period, however, the child's reasoning is based entirely on the perceptual stimulus provided by the object. His reasoning is directly related to what he can see and particularly determined by that aspect of the stimulus which captures his attention at any one instance. For this tendency, Piaget has coined the term "centration". Since judgement is made predominently on this one aspect of the situation, the reasoning of the pre-operational child is frequently distorted. In addition,

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since the child considers the situation only from his point of view, and fails to see that it has an independent construction or qualities of its own, Piaget considers the child's cognitive functioning at this stage as predominantly egocentric.

As the child progresses towards the concrete operational stage, however, both the perceptual aspects of the stimulus and the child's egocentric point of view become correlatively less important in determining his reasoning. The concrete operational stage itself might be defined as that point in the child's cognitive development when both the perceptual stimuli and the egocentric considerations are subordinated to a set of operations which allow for logical thought. Although there are wide individual differences, Piaget defines this stage as generally emerging at the seven year level. At this stage, since the internalized actions fundamental to operational thought relate to different aspects of the situation and not only to its perceptual quality, it is obvious that the child who bases his reasoning on such operations, will be able to consider simultaneously all the discrepant aspects of the situation. It is this ability which distinguishes the operational from the pre-operational child. Furthermore, since the child at this stage can tackle a problem from a number of different viewpoints, his reasoning is flexible and mobile, and lacks the rigidity characteristic of the child who relies only on the perceptual quality of the stimulus. Thus at the concrete operational stage, the child will less willingly accept the most obvious aspects of the stimulus configuration. Rather he "feels out" or probes the situation, considers one facet and simultaneously another, and only on this basis is an adequate deduction made.

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However, the child's reasoning is still restricted at this stage and the flexibility which characterizes his thought is confined to the concrete situation provided by the stimulus. The child can only reason in terms of present realities, not in terms of possibilities.

Between the sensori-motor and the concrete operational stage, there exists a transition period which suggests that maturation of brain structures is rather more gradual than a study of the three major stages at first suggests. This transition period, occurring generally between the ages of four and seven, is one in which intuitive reasoning is predominant. Intuitive thought lies half-way between true operational thought and sensori-motor intelligence. As at the sensori-motor stage, the child's actions are internalized, but in addition there is now a primitive co-ordination between these internalized actions characteristic of operational thought. This is the precursor of a complete co-ordination at the concrete operational stage.

The different groupings or structures which constitute the particular operations at the concrete operational level shall not be considered here, for these have been discussed with great thoroughness by Mc V.Hunt (1961) and Flavell (1963). There is, however, a further aspect of the stage of concrete operations which it is necessary to consider, and one that is immediately related to the present hypothesis. In his book "Psychology of Intelligence" (46.P.145) Piaget makes the following statement :-

> "Now it so happens that while classes, relations and numbers are being formed, we can see the construction in a remarkably parallel manner of the qualitative groupings that generate time and space".

This statement suggests that at a particular time in the child's life, the structures of the

brain ...

brain mature in such a way that they allow for greater co-ordination between internalized actions and so for reasoning that is determined by operations. In addition the structures which underlie these three content areas of number, space and time appear to mature simultaneously, so that the child would reach the concrete operational stage in these three areas at approximately the same time.

Another statement made by Piaget (1956 - p.450) implies a very similar notion :-

> "Concrete operations of a logico-arithmetical character deal solely with similarities (classes and symmetrical relations) and differences asymmetrical relations) or both together(numbers) between discrete aspects in discontinuous wholes, independent of their spatio-temporal location. Exactly parallel with these operations, there exist operations of a spatio-temporal or sub-logical character, and it is precisely these which constitute the idea of space".

The concurrence of time and space has also been expressed by Piaget (1954 p.321).

> "Time like space is constructed little by little and involves the elaboration of a system of relations. These two constructs are correlative".

Piaget clearly suggests,then, that intelligence is very much a unitary or global capacity, and that once it has evolved, it serves equally all areas of functioning. In other words, the theory does not provide for uneveness in intellectual development in its various content areas. Furthermore, it is axiomatic that if homogeneous development occurs in discrepant content areas, then operational constructs must appear simultaneously within one and the same area of cognitive

functioning. In this respect Piaget's theory is closely allied to that which Binet and Simon advocated. They also supported the monarchic doctrine, that intelligence is a unitary force contributing uniformly to every area of functioning. Taking the opposite stand, however, Thurstone showed by his technique of factor analysis, that intelligence is comprised of various factors, and for this reason, it is perfectly feasible that an individual may show gross uneveness between various areas of intellectual functioning.

In the present study, three areas of cognitive functioning have been selected in an attempt to determine whether something analogous to the concrete operational stage exists, and whether development within these three areas is homogeneous. This question is perhaps fundamental to Piaget's theory, for if gross uneveness in development is found, Piaget will be hard-pressed at defending his idea of intellectual homogeneity and a theory of clear-cut stages of development.

The final stage of intellectual development must now be considered. Adult intelligence is defined by Piaget as formal operational, and this constitutes the pinnacle of intellectual development. The stage of formal operations generally emerges at about eleven or twelve and follows upon the stage of concrete operations. The reasoning of the child at the third stage may be characterized as hypothetico-deductive in character. This implies that the child can reason with mere propositions instead of relying on concrete situations, and reasoning of this kind requires different operations from those characteristic of concrete operational intelligence. While intelligence at the concrete operational stage is dependent on the co-ordination of internalized actions, the child at the formal operational stage must reason purely by reflecting on these actions, by manipulating them and so deducing the correct outcome. In other words, the child has no

immediate ...

immediately present concrete situation on which he can base his reasoning, but rather must operate at the level of propositions and this he can only do by reflecting on operations which have previously emerged.

This discussion of stages has made clear a further implication of Piaget's theory of intelligence, that cognitive development occurs in a hierarchical fashion. If one traces the course of this development from the sensori-motor to formal operational stages, one notes that at each stage the structures which underlie cognitive functioning are dependent on, or grow out of, preceding structures. It is for this reason that the formal operational stage could not precede the stage of concrete operations, for the ability to reason on the level of propositions is dependent on structures which are offshoots of concrete operational structures. For this reason the growth sequence of these stages is always invariant. While the rate with which one stage follows upon another may be dependent on the quality of the child's environment, the sequence with which these stages emerge is innately determined and hence alike for every child.

(b) Motivation.

It is necessary in this discussion of Piaget's theory of intelligence to incorporate also his treatment of motivation, for it is Piaget's view that the child's drives on the one hand, and his cognition on the other, cannot be considered independently of one another.

According to Piaget, the evolvement of new cognitive structures provides the child with the drive or incentive to aspire to new levels of cognition. It is in fact the child's own cognitive functioning which spurs him on to engage in still further cognitive activity. It is clear from this motivational theory that the child does not require motivation from extrinsic sources to engage in cognitive functioning and

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secondly, that it is not possible to separate the child's cognition on the one hand from his motivation on the other. From this theory it would follow that participation in a task gives rise to incentive and that as the child becomes more proficient in the task, new and fresh possibilities of the material are suggested to him. This latter case certainly constitutes a possibility and the child is frequently more motivated by task involvement than by any prior idea of the task.

Yet there are many difficulties inherent in this theory of motivation and it has provided one of the most vulnerable points of Piaget's work. The most potent criticism is perhaps this, that a motivational theory of this kind fails to take into account the prior individual differences between children undertaking any one cognitive task. McClelland in particular has been interested in relating such individual differences in motivation to other kinds of behaviour, particularly cognition and learning. In his more recent work McClelland (1955) has shown the significant relationship which exists between the child's need achievement score and his performance and learning on a variety of cognitive tasks. Significant differences have been recorded on such tasks between children with high and low need achievement, and it has been substantiated that even the nature of the cognitive task itself can determine the extent to which high or low need achievement in the child affects his cognitive functioning.

In addition, the child's performance on a cognitive task may not only relate to the degree of need achievement but also to the extent that he is task - or ego - orientated. Whereas the task-orientated subject concentrates on the nature of the task and task material, the ego-orientated child appears to dissociate himself from the task and is concerned rather with the marks he obtains, the progress he is

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making, and the adequacy of his performance in the eyes of the tester. The extensive work of McClelland and the many follow-up studies conducted, strongly suggest that one can hardly consider cognition in vacuo to the extent that Piaget has. Piaget does not consider, for example, that the child's attitude to the task may well determine his cognitive functioning to some degree. One might certainly argue that the tests are heavily loaded with cognitive factors and that no amount of motivation will enable the child to solve the problems if he is not adequate intellectually. But here one considers extreme cases. In Piaget's tests where subtle differences exist between one substage and the next, is one not compelled to consider idiosyncratic attitudes? It is to this point that we intend returning later in discussing the results found in this study.

However, perhaps a more serious omission is this, that Piaget has not taken into account the possibility that differences in test material or subtle changes in test instructions, may to some extent influence the child's performance on a cognitive task. In the case of the Piagetean tests, where such a variety of test material is used, is it not possible that one test may be more appealing to the child than the next? Furthermore, can one not surmise that a child may show adequate conceptualization with one type of test material but respond preoperationally with another and less familiar test material, <u>although the underlying concept in both cases is identical</u>? These are perhaps the most salient questions that Piaget has as yet not considered. Further research in this direction may well point to the necessity for amendment of Piaget's cognitive theory.

Having discussed Piaget's theory of intelligence at some length, it is necessary to turn to the second major aspect of his work. This relates to the methodology and experimental design

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he has employed in testing his hypotheses. Since this question is closely allied to Piaget's final contentions and conclusions, and has an important bearing on the present hypotheses, it is necessary to consider this point in some detail.

111. METHODOLOGY

In order to test his hypothesis of stages of development, Piaget devised a procedure for which he coined the term "clinical method". Flavell (1963 P.3) has aptly stated that this procedure was later to become "a kind of Piagetean trademark" and it is certainly a method which has been followed in many of the replication studies reported to date. As the name perhaps suggests, the "clinical method" is in some respects analogous to those techniques used in psychiatric interviews and falls short on many counts of the rigidly standardized programmes frequently laid down in psychological test manuals.

The method might most briefly be described as follows:- Each child is privately interviewed by the tester who administers a particular cognitive test or battery of tests. These tests, ingeniously devised by Piaget and his colleagues, notably Inhelder and Szeminska, are outstanding in their simplicity and generally involve situations with which the child is familiar. The tests are both of the verbal and performance kind, and the solution of each is dependent upon a particular logical operation. These logical premises have been worked out at great length by Piaget, and tests have been devised in such a way, that we have immediate or direct access to the different thought processes of the child.

The tester requires each child to answer a similar set of questions, but here the method deviates to some extent from the usual psychological procedure. The questions are not standardized, nor are they administered in identical sequence to each child. Instead, the tester

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attempts to weave an intricate webb of questions around the child's original response, not necessarily the same for each child, and depending very much on the nature of the child's first reply, and the answer which is required. The clinical psychologist would consider such a method as introducing extraneous factors, and it is precisely against such variables that most psychological tests exert control.

Piaget has stated repeatedly that he does not require standardized tests and that he neither proposes nor claims to use a scientific method. The nature of man's logical reasoning is so complex that a standardized method would not elucidate the essence of logical thinking, which is not rigid or clearly defined, nor will it fall into a pattern organized by a set of fixed questions. We forfeit the richness and intricacies of conceptual thought by confining it to a fixed and narrow course. Numerous examples of the Piagetean method are described in each of his content books, and it is a study of these which shows the difficulties inherent in an uncontrolled method of this kind. Piaget himself is not unaware of the dangers vested in this clinical method, and he stipulates that at least a year of constant practice is required before a tester becomes perfectly adept. Yet it is difficult to accept that training alone can remove the dangers which are inherent in Piaget's methodology. The form which the questioning takes is such, that it is extremely difficult not to be suggestive however one guards against this possibility. There is very little doubt from a study of many of Piaget's examples that such a tendency can sometimes be discerned. The following is a good illustration of the suggestive manner in which problems are sometimes posed (1952 P.175)

/Gon (7;2) ..

Gon (7;2) If we made a necklace with all the wooden beads and a necklace with all the brown beads, which would be longer? - They'd be the same.
Draw the necklace with the wooden beads. (Gon drew a row of brown beads close together). Are all the wooden beads brown? - Oh no! There are two white ones (adding them). Now draw the necklace of brown beads. (He drew them close together in a line). Which is longer? - They're both the same. - Why? They're the same. Are the necklaces the same? - One of them has only brown beads, and the other has white ones as well. - Then which one is longer? - They're the same. - How many brown beads are there? - About forty. - And how many white ones? - Two. ,- Then which is longer? - Oh the wooden one! - Why didn't you see that before? - I thought they were the same".

Furthermore, since there is no standardized procedure, considerable weight is placed upon the interpersonal relations between the child and the tester, the manner in which the tester poses the questions, and the form which such questions take. It is possible that even subtle differences in the nature of these questions can influence the child's response to some extent. Another difficulty arises from the point that Piaget seldom quotes the number of children he uses, and perhaps more important than this, he does not state the number of tests administered to each child, or the percentage of tests quoted from each child's protocol in his content books. A further difficulty in Piaget's methodology, and one that makes replications of his studies particularly difficult, relates to the scoring procedures which Piaget has adopted and hence the reliability of the tests. The scoring of a child's test protocol depends entirely on

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the rating ability of the tester. It follows from this that different testers might come to significantly different conclusions in their rating of one and the same child. Piaget has apparently made no attempt to determine the degree of concordance between ratings of different testers. This is by no means to discredit rating as a psychometric procedure provided that adequate criteria are stipulated on which the rating may be established. It is this latter provision which has not been made by Piaget. In making the particular ratings one is frequently hesitant as to the exact categorization of a response and it is left very much to the initiative of the tester to deduce, from one or two examples given in a particular content book, the stage of the response in question. This makes the rating procedure highly subjective, and for this reason open to error. From this it follows that the comparison of results obtained by a group of children, as rated by different testers may well lack validity. This is one further difficulty apropos a method which lacks standardization.

There are also important aspects of the experimental design which require consideration. Two basic hypotheses may be generalized from Piaget's theory of cognitive development. The first of these is that cognition develops in clear-cut sequential stages. The second is that intelligence is a homogeneous unitary force which, at any one period in the child's life, contributes uniformly to every area of his cognitive functioning. In order to test these hypotheses, Piaget has predominantly employed a cross-sectional design. Taking a group of children between the ages of two and perhaps fifteen or sixteen, he has administered to each child, individually, a test or series of tests which have been devised to study the child's cognition at any one of the specific stages. On the basis of these results, he was

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able to define, within broad limits, particular age levels at which cognitive functioning took characteristic forms. This evidence Piaget accepts as confirmation of his hypothesis, that cognitive development occurs in clear-cut sequential stages in the life of every child. The confirmation for his second hypothesis is a generalization from this latter finding. The fact that marked trends in functioning were noted at particular ages in all areas of cognition led Piaget to assume that broad constellations of behaviour arrive at the same time, in all areas. It is interesting to note that in the majority of replication studies reported, most of which are in strong confirmation of Piaget's theory, an identical cross-sectional approach has been employed.

There are, however, a number of striking difficulties in making deductions on the basis of this method, as Piaget has done. In the first instance, it seems clear that only a longitudinal design will suffice to show that every child passes through an invariant sequence of stages. Unless one follows the individual's development over a number of years, there is no basis for accepting the hypothesis that his cognitive development follows a specific course, alike for every child. The cross-sectional design, while it shows the presence of certain trends, is not adequate to determine whether a child, at any one level of development, has passed through the preceding stages in the sequence Piaget predicts. In the second instance, it is of doubtful validity whether one can generalize that broad waves of development cut across different areas of cognition simultaneously, on the basis of Piaget's method alone. In order to state that development is alike in space, time and number conception, this would surely necessitate that one and the same child is tested in all these areas, at approximately

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the same time. The fact that three seven year old children, one of whom is tested on number, the other on space, and the third on time tests, show an analogous level of cognitive functioning does not necessarily permit the conclusion that one and the same child at this age will function at the identical level in all three content areas.

Finally, one might consider the possibility that Piaget's findings are in fact determined by the experimental method which he has used. It is clear that a purely cross-sectional study will reveal a pattern of results very similar to that which Piaget has found. There will obviously be a clear-cut progression in scores with age, the older children giving predominantly better responses that the younger. The problem, however, is this :- What constitutes a significant difference between one age group and the next in order to designate the latter group as having reached a new stage of development? On the basis of what criterion can one define suitable "cutting points"?

There is still another difficulty which is inherent in Piaget's experimental design, although this constitutes perhaps a subtler point. Piaget's books on number, space and time conception each present a series of tests which investigate different facets of the concept under discussion. Each test requires for its solution a different logical operation. These operations, however, emerge simultaneously in the life of every child, so that a significant correlation should exist between the tests constituting a battery in any one content area when these tests are administered to the individual subject. However, it appears from Piaget's content books that protocols of different children have been published to illustrate the attainment of any specific stage on the different tests constituting a battery in a given content area. If it is to be shown by Piaget's theory that one and the same child functions at the same level on all

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tests within a particular conceptual field, it is surely of fundamental importance that the child is represented on all these tests. The failure to support such an important implication with the correct experimental data, must be seen as an important omission in Piaget's work. This criticism can be taken still further. The individual tests devised to investigate a particular concept are often divided into sub-sections. These two or three subsections might constitute a single test belonging to the battery. A test which comes to mind is that of cardinal and ordinal one to one correspondence. Piaget quotes results on the different subsections constituting a test but the results are in fact taken from the protocols of different children. Thus Piaget quotes the results of subject A at stage three on subsection one of the test, the results of subject B at stage three on the second subsection,and finally the results of subject C as illustrative of stage three on the third subsection. There is no experimental proof therefore that subject A is at stage three on all subsections of the test. One might well ask why Piaget fails to quote the results of subject A on all three sub-divisions, if he attains the same level on these. This omission is one that renders Piaget's results unintelligible in terms of his original hypothesis, and certainly makes further deductions difficult. In the present study, a slightly amended procedure has been used with the aim of noting whether any clear deviation from results obtained by the Piagetean methodology is found. In this case possible reconstructions in experimental procedure shall be suggested.

We have seen it well to labour this point of methodology, for in our opinion, this may well be the "root of evil".

IV. NUMBER, SPACE AND TIME CONCEPTION

The previous sections have dealt with Piaget's methodology, with his theory of cognitive development in general, and with the major implications which this theory has given rise to. At this point, it is necessary to confine attention to the three specific areas of Piaget's work which have been the subject of the present project. Piaget's three books on number (1952), time (1955), and space (1956) have been referred to as his "content" books and incorporate much of the work characteristic of the later part of his career. In these books Piaget's principal concern is with giving practical application to his earlier theoretical tenets, and in so doing he proposes to show that the logical operations which he hypothesizes are inherent in the organization of normal adult thinking, are essential to an adequate concept of space, number and time. It is this aspect of Piaget's work which perhaps constitutes its most ingenious quality, for he has taken the most common aspects of our everyday thinking and experience and proposed to show that each relates to a specific history of development. In these three content books Piaget has systematically attempted to trace the development of the concepts of number, space and time from their earliest inception through to the level of adult functioning. Piaget has shown that, within these three areas, the course of cognitive development is highly analogous and that three specific and parallel stages are to be discerned in each. Before proposing to test this hypothesis one must briefly consider the most salient research projects which have been undertaken within these three areas of cognition. Only one study, that of Dodwell (1962), follows the immediate lines of the present project, and this relates only to the area of number conception. However, it is intended to discuss

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additional research which in one or other way has bearing on the present hypothesis.

A. NUMBER CONCEPTION AND RELATED RESEARCH.

It appears from a survey of the literature that Piaget's work on number concepts has evoked more independent research than any other of the content areas. There is little doubt that this stems from the interest which this field holds for the educational psychologist in addition to its ethnological implications. Before considering these studies, it is necessary to define what Piaget actually implies by the term "number concept". Piaget has never interested himself in the purely arithmetical implications of educational programmes. Rather it has been his concern to trace the development of certain logical operations which he considers fundamental to the concepts of number.

Perhaps the key premise in Piaget's number book, and one that defines most clearly the terrain of his research, is the following:- "Our results do in fact show that number is organized stage after stage in close connection with the gradual elaboration of systems of assymetrical relations (qualitative seriations), the sequence of numbers thus resulting from an operational synthesis of classification and seriation. In our view logical and arithmetical operations therefore constitute a single system that is psychologically natural". (Piaget 1952 P Vll)

Classification refers to the child's ability to discriminate like qualities common to a group of objects. Seriation relates to his ability to discriminate unlike characteristics in such objects on the basis of which they may be seriated. The operational child must therefore be able to consider any particular object as belonging to a given class on the basis of common properties, and in addition he must simultaneously differentiate that object from others, all of

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which have common elements, but which differ in respect to one underlying quality.

In addition, since number is dependent on two major operational constructs which emerge simultaneously, owing to adequate maturation of brain structures, the child will manifest a large variety of number concepts at approximately the same time in his development. "To sum up", says Piaget, "we can now see why the additive hierachy of classes, seriation of relationships and operational generalization appear approximately at the same time, about the age of six or seven, when the child's reasoning is beginning to go beyond the initial prelogical level. The reason is that class, assymetrical relation and number are three complementary manifestations of the same operational construction applied either to equivalences, differences, or to both together". (Piaget 1952 P.184).

This treatment of number is then clearly to be differentiated from a purely arithmetical consideration. The child's ability to add one and one or subtract one from ten, may well be attributable in the young child to a memory factor which is the result of constant drilling on the part of the teacher. Logical thinking, while dependent on adequate environmental matching, is correlative with the maturation of certain brain structures. Before this critical period, training on the Piagetean concept tests would only result in an inadequate and short-lived mastery of the task. The stability which is characteristic of logical thinking, is directly attributable to the maturation of new brain structures. While Piaget would hardly deny that the child who uses number with some understanding in the solution of an arithmetical problem has a good operational conception of number, it is necessary in studying Piaget's own work, and in considering relevant studies, to keep in mind the specific definition of number which Piaget has formulated.

RELEVANT STUDIES ON NUMBER CONCEPTION

The studies on number which have been undertaken have considered various aspects of Piagets' theory, but the main interest has been focussed on determining whether development in this area does follow a strong sequential pattern of stages, which Piaget claims to have found. The studies, with few exceptions, have followed very much the design of Piaget's original work and there is no doubt that the practical difficulties involved have staved off attempts at a longitudinal procedure. While many of these studies have considered interesting implications of Piaget's theory and confirmed his general findings, it must be kept in mind that the cross-sectional approach which has so frequently been adopted, sets certain limits to the deductions which can ultimately be made.

Blair Hood (1962), in a well conducted experiment, confirmed Piagets hypothesis that certain clear-cut stages of development in number conception could be found in a group of children between the ages of four years, nine months, and eight years, seven months. The level at which any one child was performing, however, was more closely related to his mental age as determined by the Terman Merrill "L" scale, than his chronological age, and the exclusive reliance on chronological age tended to mask somewhat a clear-cut patterning of results. Within the same chronological age range, children of all stages could be found and this variability could be attributed to differences in mental age. While Piaget has concentrated purely on chronological ages, he stresses repeatedly that any one stage does not emerge at an identical age in the life of every child. It is only the sequence of stages which is invariant. Piaget's theory furthermore implies that a progression from one stage to the next is related to certain structural changes in the brain which would correspond well with the

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finding that stages of development are related to mental age. Blair Hood's results show clearly that on each of the Piagetean number tests used in this study, children who are at the third stage have a higher mental age than children of the same chronological ages but with lower mental ages. In addition, the proportion of stage 1 to stage 111 children changes radically with progression in age; the percentage of stage 1 children decreasing with a correlative increase in the percentage of stage 111 children. The greatest transition step, on the basis of chronological age, appears to be between the ages of six and eight. These results are directly in line with those of Piaget and confirm his prediction that the concrete operational stage emerges generally at the seven year level.

There is a further conclusion which may be reached from the analysis of Blair Hood's results and a point which the author himself has not developed. In calculating the average mental ages of two of his subgroups, the six to seven and the seven to eight year olds, he found that these only differed in mental age by a fairly small margin of three months. Yet on certain tests, for example, that investigating the child's ability on the "one to one correspondence test" only 29% are at the third stage in the six to seven year group and 100% at the same stage in the seven to eight year group. This highly significant difference exists, in spite of the small difference in the average mental age between these two groups. There are two alternative explanations which may account for this difference. In the first place one cannot exclude the possibility that the small difference in the mental ages is of sufficient consequence to determine differences in performance, on several independent number tests. On the other hand, it is possible also to hypothesize that the child in the seven to eight year group has at least a

years /...

year's extra schooling and that this additional experience can account for the differences assessed between the two groups. This second alternative would also fit into the framework of Piaget's theory. From these results one might deduce that adequate stimulation at an age when the brain is undergoing further maturation leads to the propagation of a new stage of development. On the other hand, stimulation before this potential period of maturation, seems to be of little avail to the development of new brain structures.

Blair Hood's study group also included a number of educationally subnormal children (IQ below 75 and chronological ages between 10 years 3 months and 15 years nine months), and a group of mentally defective subjects (chronological ages 9 years 5 months to 41 years), who attended a training centre and received no normal educational tuition.

The criterion which Blair Hood adopted was the following: that both the subnormal and mentally defective children should show a greater degree of conceptualization than a normal group of compatible mental age, if the two former groups had profited significantly from the experiences which accompanied their added years. Blair Hood, however, found that both groups had not progressed beyond the stage of development which in general was characteristic of the mental age at which they were fixated. While this finding strongly suggests that the level of cognitive development is heavily determined by the general level of maturation in the underlying brain structures of the subject, one should not, however, overlook the point that these subjects undoubtedly lived sheltered lives owing to their handicap, and that they were subsequently not exposed to the variety or degree of stimulation common to the normal child. These reservations, while they are

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certainly important, do not detract entirely from Blair Hood's conclusion that not mere age but "mental stature" is predominantly important in determining the subject's level of cognitive development. Until the brain has matured sufficiently and operations have emerged, reversibility of thought is not available to the subject and the Piagetean tests cannot be tackled with any degree of success.

Blair Hood's results are thus in strong confirmation of Piaget's contentions, that certain broad trends of development characterize the growing child. Since the study has been conducted on large numbers, and apparently with much precision and control, it must be considered as one important backing for Piaget's contention of stages of development.

Elkind (1961) has also reported a study on the development of number concepts, the conclusions of which are in staunch support of Piaget. Conducting his experiment on similar lines to that of Piaget, he administered Piaget's test of "additive composition of classes" to three groups of children ranging in chronological age from five to eight years. This test requires that the child simultaneously considers an object as an entity and as part of a larger whole. Elkind found that there was a marked shift from stage 1 to stage 111 during the five to eight year old period. On the other hand, the percentage of stage 1 responses dropped significantly from 50% at the five year level to 8% at the eight year level. The form which these results take follows closely the trend of development which Piaget proposes, and suggests that this constitutes a critical period during which the brain structures basic to operational thought mature. Elkind's study confirms still another aspect of Piaget's theory of concept formation. Reversibility, or mobility of thought is, according to Piaget, the ability to coordinate various aspects of

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the problem situation, and on this basis to deduce the correct solution. Elkind has shown in his study that prelogical children were capable of formulating single operations, but failed in co-ordinating or grouping these single operations into a logical whole.

In evaluating these findings, however, the point should not be overlooked that the same difficulties which were found to be inherent in Piaget's methodology are equally applicable to the above studies. The results certainly show a progression in scores with age, but one can neither deduce on the basis of this experimental procedure whether the growth sequence with age is invariant for every child, nor is it possible to state with any certainty what constitutes a specific stage of development. The degree of transition between one age level and the next may be calculated but there is no criterion as to what constitutes a stage, in terms of the divergence between one age level and the next. Even though the development is not smoothly monotonic, can the pattern of results be analyzed into clear-cut stages, or do the results simply fall into a pattern that may be represented by a line of progression which gradually expands with additional maturation?

Wohlwill (1960), considering the practical difficulties involved in a longitudinal study, proposed that a scalogram analysis be applied to the results obtained from his cross-sectional approach. This analysis, he claimed, would give the same information about the developmental sequences as would a longitudinal study. A series of number tests, which were specifically devised by Wohlwill for children at various developmental levels, was administered to each child. An analysis was then conducted on the pattern of successes and failures in order to determine whether these results constituted an ordinal scale corresponding to the ordering

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of the tests themselves. Guttman's technique of scalogram analysis showed that the results were scalable and that furthermore three clearly defined stages of development in number conception could be differentiated. These stages Wohlwill has defined in terms closely analogous to Piaget's description, suggesting a progression from perceptual to conceptual thought and a growing propensity to reason in terms of abstract rather than concrete thought processes. Wohlwill considers, therefore, that the emergence of three broad trends of development, on the basis of results obtained on his tests, must be taken as an important confirmation of Piaget's theorectical contentions. There is little doubt that if Piaget's theory is correct, the results of a child on a series of tests which vary in conceptual difficulty should fall clearly along an ordinal scale, and the application of such an analysis might be considered as an important statistical tool.

The study which is the most relevant to the present thesis, and one that must be regarded as of considerable importance in the light of the Piagetean theory, is that conducted by Dodwell in Canada (Dodwell 1960 and 1962). Certainly within the area of number conception and probably within the entire framework of Piaget's work on cognition, this is one of the few replication studies which has been conducted in an attempt to study the stability or consistency of the child's responses on a series of tests appertaining to the same content area. There is a particular need for studies of this nature for several reasons. In the previous number studies which were quoted, we proposed as a criticism the inability to deduce adequately, on the basis of the experimental design, what constitutes a stage and a significant progression from one step to the next. If it can be shown that each child responds consistently on tasks which are proposed as tests of a particular level of maturation, this should provide a fairly

adequate /...

adequate criterion that the child is functioning at a clearly definable stage in Piaget's sense. Piaget's theory implies that intelligence is a unitary or homogeneous capacity, so that the child at the concrete operational stage should function uniformly on all tests of cognitive development at this stage. Dodwell's results are particularly interesting. He found that when five Piagetean number tests were administered to each child in a group of 250 children, composed of five to eight year olds, it appeared that a child could be in a stage one for one type of material and situation, and in stages two and three for the others. In other words, no general trend in the pattern of test results for any one child could be found. When Dodwell, however, calculated the number of questions answered correctly in any one group, he found a direct relationship between the number of operational responses recorded and the age of the group. This finding is exactly comparable with the findings quoted in the previous studies. Dodwell's experiment, however, sounds a strong note of warning against making sweeping generalizations from the above studies. If Blair Hood and Elkind could come to the same general conclusions as Dodwell, predicting a sequential development on the basis of the average number of correct answers given in any one age group, and yet completely mask the fact that any one child at a given stage shows inconsistency in development, one can obviously only draw very limited conclusions from studies which employ a cross-sectional design of this nature.

It is to some degree difficult to explain Dodwell's results in terms of Piaget's theory, for his study places considerable duress on the idea of a homogeneous or unitary level of maturation at any one period in the child's life, a capacity which would allow for consistent functioning on all tests. Dodwell (1960) reports further interesting findings. For certain tests

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no marked change was found between the five and eight year levels, whereas for others (conservation and unprovoked correspondence), a notable progression was observable over this period. A third variation was found in the case of cardination-ordination and seriation tests, where no clear trend could be defined at all.

"Therefore, although a child could be assigned with a fair degree of assurance to one of the three categories for each test subgroup, there is no consistency of stages within individuals, nor are the age trends similar for the different subgroups" (Dodwell 1960 P.202).

A unique number study was undertaken by Price Williams (1961) in which he administered Piaget's test of "Conservation of continuous and discontinuous numbers," to a group of illiterate Bush West African children in Central Nigeria. As far as could be assessed, these children ranged from five to eight years of age, and were divided into five groups, each comprising nine children. The results obtained from these groups appear to be clearly in line with those of Piaget, showing a general trend from perceptual to conceptual thought, with progression in age. Analysis of results show that a particular transition step can be discerned between the seven and eight year old groups, which would correspond well with Piaget's finding that the concrete operational stage emerges approximately at this age. It was noted in particular that the third stage children qualified their answers in terms of the operations which the experimenter had carried out in conducting the experiment. This would serve as a clear illustration of Piaget's contention that an operation is an internalized action. The results of Price William's study, lend

themselves / ...

themselves to several interpretations, but it is clear that the tendency to develop from a rigid and concretistic way of thinking, to a reasoning characterized by reversibility and plasticity of thought, seems to be the product of increasing age in both literate and illiterate children, and largely attributable to a neurophysiological maturation. It seems to be this maturation which opens new horizons for the developing child, irrespective of the cultural milieu. This study, while interesting must, however, be considered as limited in its implications. The number of subjects in each group is small, and the investigator could only make a rough assessment of their age. Furthermore only two of the Piagetean number tests were administered to each child, and an assumption purely on this basis is inadequate. Finally, we have little insight into the environmental stimulation which such children receive, the maternal codes or games which they play. The lack of schooling may well be compensated for by other forms of stimulation which constitute notions foreign to us. These are questions on which only further investigation can shed any light.

The above studies have all attempted to determine whether there are clear-cut sequential stages of development in the conception of number, and whether these may be related to the Piagetean model of conceptual development. In general the tone of these studies is one of confirmation but as was already pointed out, the experimental designs employed were with few exceptions, not adequate to confirm the original hypothesis. This makes interpretation particularly difficult and allows for ambiguities.

Another trend of research which has been

undertaken / ...

undertaken recently in the area of number conception, relates to the effects of training on the child's performance on the Piagetean number tests. These studies followed on a spate of criticisms that Piaget had failed to consider adequately the environmental effects on the development of number conception and particularly the effects of instruction or training. A theory of fixed stages, these critics believed, was tainted too much with an element of predeterminism. In general, the studies undertaken made an attempt to determine whether the succession of stages could be accelerated by the effects of training, and whether, in fact, the sequence of stages remained invariant even when training was instituted.

An early study of this type was conducted by Churchill (1955) in which she administered a series of Piaget's number tests to sixteen five year olds. On the basis of the scores obtained she divided children into two groups, one of which was not seen till the end of the month, while the experimental group received training in number situations for an hour twice weekly. On the retest series the experimental children were found to perform at a significantly higher level and to show a marked improvement over the control group. Churchill interprets these findings as evidence that education and training in the specific area of number concepts itself, can accelerate the emergence of stages, and that invariance in the sequence of stages is not necessarily the code for every child. With the institution of proper training in number concepts, the child might pass from stage I to stage III with no intervening period of development. The study however is inconclusive on several points. Since Churchill reports on retest findings which

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were obtained directly after the training was instituted in the experimental group, their marked improvement may well be attributed to a memory factor, and not representative of an underlying conceptual development. No follow-up study was introduced to test the stability of retest scores in the experimental group. A consistency of performance would show that the intensive training programme did in fact accelerate the development of certain brain structures. In the second instance, these results may well be accounted for by Piaget's cognitive theory. Inherent in his principles of assimilation and accommodation there is the assumtion that the more stimulation the child receives, the greater becomes the potentiality for responding adequately to such stimulation. Certainly this principle is only operative if the brain structures have matured adequately but once maturation has occurred, the level of performance is very much determined by the environmental stimulation which the child encounters.

A strong attack has been made recently by Kohstamm (1963) on several tenets of Piaget's theory, and particularly his failure to give adequate consideration to the effects of training on the conceptual development of the child. "It does seem," he says, "as if Piaget considers the environment in which the child grows up as a relatively constant factor, a factor sine qua non, but not a very variable one." (Kohstamm 1963 P.316) Directing his attention specifically to the area of number conception, Kohstamm conducted a study to investigate whether the child's performance on the test of additive composition of classes, would reveal sporadic improvement when a training programme was instituted. A group of 60 five year olds were

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divided into three groups, matched as far as possible in age, sex and intelligence. To each group, a test of additive composition of classes was administered, but the test material itself differed for the three groups. Whereas the first group received only verbally presented classes, the second group was presented with pictures which illustrated the inclusion relations. The third group were given a set of Lego Blocks, and were required to state the relations which existed between one class of blocks and another. Training which was introduced during each session took the form of instructions and careful explanations as to the relations which existed between the two classes involved. A retest period was instituted directly after the training series for each of the three groups, but in addition a follow up study was conducted on the third group three weeks later, in order to test whether the newly acquired responses through training had been retained.

The results of Kohstamm's study are particularly interesting. He found that the children in all three groups benefitted from the training procedures, but the percentage improvement varied with the type of training material. As might be expected, the smallest percentage of improvement was found in the case of Group I children where presentation of the problem took the least concrete form. Particularly the Group III children appeared to have benefitted from the training programme and, in addition, the follow-up study three weeks later showed a remarkable analogy to the retest scores. This clear stability in improvement brought about by training, confirms the assumption that the changes brought about were conceptual in nature and related to a structural counterpart in the brain. The

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results seem distinctly to show, then, that the child who is trained on number concept tests will earlier show concept formation in this area than the child who receives no training.

While Piaget's theory would make provision for improvement in conceptualization through increased training, if, as was shown in this and the previous study, a child can progress immediately from Stage I to Stage III as a result of a short but intensive training, there is something to be said in favour of the criticism that Piaget has not given adequate attention to environmental forces. However, there are several points that come to light in Kohstamm's research which should not be overlooked in considering the relevance of his conclusions. In group one, the "success" children were found to be older than the rest by an average of four months, but not more intelligent, according to the Pintner Cunningham Intelligence Scale. In the second group, the eight "success" children were on the average not older than the remainder of the group, but their intelligence test scores revealed superior performance in comparison to the partial-success and non-success children. Furthermore, even though six of the twenty children in Group one, and eight of the twenty children in Group two showed third stage responses after training, there were also a significant number who showed only partial improvement, or no improvement at all. Although the author fails to consider this point, is it not possible to explain these intricacies in terms of Piaget's theory? In considering the six success children in Group I, one might hypothesise, that since these children were older than the remainder, the maturer brain structures were more susceptible to environmental influences and hence training effects. In the case

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of the second group, since the "success" children were also the most intelligent though not significally older than the remainder, one might assume that these children were characterized by a maturer mental stature, and so had a greater propensity towards responding to environmental stimulation. The extent of overlap which Kohstamm found in both groups one and two must also signal a warning against accepting the predominant effects of training on conceptualization too readily. The question emerges as to what constitutes the basis of discrepancy between those children who receive training on tests and show improved conceptualization in this area, and those children who receive the same training but show no trend in this direction. Since the environmental stimulation must be considered as a factor common to both groups, can one not attribute the differences noted to discrepancies in those inbuilt structures of the brain, which interact with this stimulation? The fact that some children do not benefit from training, may be indicative that brain structures, which underlie a concept of number, are not ready to assimilate and accommodate environmental stimulation in Piaget's sense of the terms. These, however, are only assumptions, and one interpretation of Kohstamm's report.

In conclusion, it is perhaps clear from Kohstamm's study that Piaget's tests do not necessarily tap the full extent of the child's conceptual development at any particular stage. Certainly, in the case of the above study, a straightforward replication study would have shown that many children were in stage one, whereas only a short training programme was sufficient to evoke third stage responses from a small group. An identical training resulted in no improvement in the remainder of the subjects, who

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still remained at the stage one level. It is clear that between these two groups of subjects, there is a subtle difference, not elucidated by the Piagetean tests in their present form. This is perhaps as far as Kohstamm's criticisms are valid. At this stage, however, one cannot condone entirely his other criticisms, that Piaget has not made place in his theory for the effects of excessive environmental stimulation.

There are finally a few miscellaneous studies which may be considered. Dodwell (1960), in a study conducted on 250 children found no significant sex differences when five number tests were administered to the group. In addition he related Socio-economic status to the child's score on several number tests but no significant difference was found between the three groups. These were constituted by children whose fathers were professional workers, clerical and skilled tradesmen, and semi-skilled and unskilled tradesmen. There was, however, a trend towards higher number scores in children of the higher Socio-economic groups. Piaget's theory favours such a finding, as the quality of the home environment determines the degree of environmental matching. It is particularly these latter implications of Piaget's work, which require experimental investigation. Such research will provide further insight into the question of matching, and take into account such factors as the child's relations with his parents and peers, and the extent to which these factors impinge on the cognitive development of the child. It may well be that the child's personality as related to his earliest liaison with others, can affect his conceptual development. These questions have as yet not been considered, but they may well provide interesting areas of research.

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In concluding this section on the research conducted in this area of number conception, it might perhaps not be unfitting to say that any fixed conclusions at this stage would be premature. Studies appear both to confirm and reject Piaget's basic premises but discrepancies in the conclusions may frequently be related to the research design which has been adopted, or to the fact that different facets of Piaget's theory have been considered. It does, however, appear that the general trend of development which Piaget predicts does receive support from replication studies. Whether clear-cut stages can be defined in this pattern, or whether the sequence of stages is invariant, is only a matter of conjecture at this point. Before any general conclusions can be drawn it is necessary also that replication studies undertaken in the area of space and time conception, be considered.

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B. SPACE CONCEPTION AND RELATED RESEARCH.

Piaget's book on the child's conception of space (1956) presents more clearly than any of his other content books the basic premises of his theory, making particular reference to the stage of concrete operations. It might well be taken as the chief source book for a clear understanding of the concrete operational stage, and while the theoretical contentions are directly applicable to spatial conception, the course of cognitive development which Piaget describes may well be taken as representative of operational development in general. For this reason, it is intended to give more emphasis to the theoretical details of the book than we shall do either in the case of number or time conception.

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According to Piaget, the adult's conception of space is dependent on the evolvement of adequate operations. These operations are, in short, internalized actions, which as a result of maturation of brain structures, are capable of co-ordination and hence the mobility of thought which results. Their origin is therefore identical to that of operations underlying time and number conception. While space, number and time concepts are comparable on this basis, they differ markedly with regards to the nature of their underlying operations. Piaget's theory requires that a child who has developed a concept of number must at any one instance be able to relate an object to a particular class, and simultaneously consider that object as an entity with properties of its own. The operations underlying space, however, "deal with part - whole inclusions for a single object" (Piaget 1956). In other words, the object is not related to a class of objects with which it shares certain common elements, but is rather considered as part of the spatial field existing in particular relationship to other constituent parts of the field. While these operations are clearly different in character, their development is, according to Piaget, exactly parallel, and for this reason they emerge at approximately the same time in the life of every child.

Piaget's work on the concept of space is characterized by an attempt to show that spatial concepts develop gradually in sequential stages, common to all children. Spatial conception is, therefore, not an immediate product present from birth which, however, one fails to tap until adequate tests are put to the child. This latter view is held by the Gestaltists who, it is interesting to note, conducted experiments exclusively on adults. From their research,

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in which Euclidean concepts were detected in their subjects, they concluded that this mature or advanced conception had existed since birth and underwent no particular change during the course of the child's development. Piaget, on the other hand, is resolute in his belief that the earliest concept of space is not euclidean at all, but that each child passes from the earliest stage of spatial perception, during which he judges the spatial characteristics of the object entirely on the basis of what he can see, to a stage of spatial conception which is characterized by operational thought. Consider a number of objects which must be placed in perspective. Spatial conception can only come about provided there is co-ordination between the internalized images related to these objects in the spatial field, on the basis of which the child may discriminate one viewpoint from other irrelevancies. This perfect co-ordination occurs only at the stage of concrete operations when the brain structures are sufficiently mature and there is perfect equilibrium between internalized actions already existent and those which are being internalized. In the case of a single object (topological space), the shape is also gradually abstracted as a result of a great deal of activity on the part of the child. Only on this basis are various aspects of the figure, its contour, shape and size synthesized into a meaningful whole. This is the result of a sporadic process of development extending over several years.

The picture of spatial development which Piaget has constructed shows clearly that he is an exponent of a development in clear-cut stages. It is certainly a theory which takes diametrically the opposite viewpoint to that adopted by the Gestahltists. However, it seems that several reservations should

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be made before drawing a sharp line between Piaget's treatment of spatial conception on the one hand and that of the Gestahltists on the other. The following statement of Piaget's may be considered (1956 P. 459). "Thus sublogical operations whose structure is based on proximity rather than similarity, as is that of logical operations, lead to the formation of continuous unitary schemata. In other words, they lead to complete and continuous spaces, whereas logico-arithmetical operations lead to discrete wholes..." From this statement, it is possible to deduce that both Piaget and the Gestahltists have a very similar idea of the final structure underlying the adult conception of space. Whereas the Gestahltists believe that Gestahlten or wholenesses isomorphic to the object constitute the brain structures underlying its spatial conception, Piaget's theory suggests that as the child progresses to an adult level, the logical operations which underlie his concept of space also tend more and more towards the formation of unitary schemata or wholenesses in the Gestahltist's sense. Certainly Piaget would not concede that these unitary schemata are present from birth, but his theory of adult space conception is in some important respects compatible with that of the Gestahltists.

In concluding this discussion, it is perhaps of relevance to note that Piaget stresses the fundamental importance of sensory motor activity for adequate development of spatial conception, far more than he emphasizes the importance of this activity in either his time or number books. It is this activity which he considers as the fountain head underlying operations fundamental to spatial conceptualization. It might well be that discrepancies which were noted in the present study, between number, space and time tests, relate

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pertinently to this point.

RELEVANT STUDIES ON SPACE CONCEPTION.

While Piaget has devoted much time to a practical application of his theory in this area of cognition, many of his premises require confirmation from sources other than his own immediate studies.

It is a remarkable fact that Piaget's work in this field has only recently evoked any interest, and the only fruitful studies have been confined to British research workers. The studies which are of relevance to the present thesis all follow the lines of a replication of Piaget's original testing programme. The tendency in research has been to determine whether in fact a concept of space develops in the clear-cut stages which Piaget defines; and whether elementary topological notions precede a euclidean concept of space. As far as could be determined only three studies of consequence, that by Lovell et al (1959) E. Peel (1959) and Cowley and Murray (1962), have been published in English during the last few years. These will be considered in some detail.

Lovell et al (1959) conducted a large scale study on 150 children, 75 of each sex, ranging in age from three years to five years eight months. To each child he administered six Piagetean space tests, as reported in Piaget's book on spatial conception, making only a few amendments where necessary. The major hypothesis which Lovell proposed to test was whether topological properties and relations were earlier detected by children than euclidean properties and relations. This would follow directly from Piaget's theoretical contentions. On four of the six tests Piaget's hypothesis was confirmed. Topological shapes were more readily

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constructed and identified than euclidean relations. A rank order for difficulty of items was calculated in the case of each test and the relative difficulty of items found to remain almost the same from group to group. Within each age group, topological problems appeared to be easier than euclidean problems. On two of the tests, however, that of "elementary spatial relations" and "perspective of a straight line", Lovell distinguished several discrepancies between their findings and those of Piaget. In the case of "elementary spatial relations", the drawing of euclidean properties was found to be significantly more difficult than the drawing of topological properties. However, the construction of figures was found to be easier for children than the drawing of these, and this trend was found applicable to figures of both euclidean and topological character. Piaget has made no provision in his theory for this finding. The authors themselves offer no explanation for this trend, and from the form of the test results it is difficult to make further deductions. It should be taken in account however, that the children, even those in the third group, were very young and that the authors might be tapping purely the motor difficulties which are common to very young children. Lack of experience with a pencil, and poor muscle control may well account for this finding.

In the test of "perspective of a straight line," Lovell found a consistent improvement in performance with age, on all sections of the test, and this finding is in line with Piaget's theory. Two points of discrepancy were, however, noted. In the case of some children, a good straight line could be constructed in one or two subsections of the test, but on the remaining two, performance was poor and not in line with the predicted outcome. Thus, for

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example, a child might construct a line in perspective between two end poles mounted midway on adjacent sides of a rectangular table, but fail to construct such a line when the two outside matchsticks were placed at the end of a chord of a round table. This finding is difficult to reconcile with Piaget's theory, for if a child has attained operational reasoning, this should be employed on all subsections of the test, provided that Piaget's concept of a homogeneous intelligence is valid. The presentation of Lovell's results and his experimental design make it difficult to demarcate clear-cut stages of development in Piaget's sense, but his general finding that topological concepts are found consistently earlier than euclidean concepts at all age groups, must be considered as an important step towards the confirmation of Piaget's theory.

The article of Peel (1959) is unfortunately only a short extract of a large unpublished study undertaken recently to investigate the development of spatial conception on the basis of the Piagetean tests. In this article, the work of two co-workers is of particular relevance to the present hypothesis. The first of these research studies is that conducted by Page, who administered a test of "elementary spatial relations", to 60 children aged three to eight years. The results obtained are clearly in support of Piaget's contention that children's drawings do progress with age, and that specific spatial concepts are correlated with certain clearly defined age levels. In addition, when Guttman's technique of scalogram analysis was applied to the results, the coefficient of reproducibility was found to be significant. This implies that the results constitute an ordinal scale which corresponds exactly with the age scale. Roughly four zones of demarcation were noted in the scale, and these correspond significantly with the phases Piaget suggests. The concrete operational

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stage Page puts at 6.7 - 7.7 years of age, which corresponds well with what Piaget found.

Another study by Ferns, which is also reported briefly in Peel's article, is again in support of Piaget's contentions. The results of this study conducted on fifty five children of the same age as Page's sample, were clearly in support of the hypothesis that topological shapes are recognised with less difficulty than euclidean shapes. Ferns put forward an interesting explanation of the general trend which she found in her studies.

"We may put it in another way", she says "that geometrical abstractions implied in the straight line, in the angle, and in dimensions are not appreciated by young children, until the more primitive perceptual forms possibly closely connected with the more undifferentiated movements and vision the young child is capable of exercising, have been experienced" (Peel 1959 P. 90). This suggests that as the child progresses in age, he responds less and less to the situation in its globality, but differentiates specific aspects to which he responds. This last concept is a particularly interesting one and one that might well account for the tendency to recognise relationships of proximity, order, enclosure and continuity, before the metric relationships fundamental to a conception of euclidean space.

An interesting study is reported by Cowley and Murray (1962) in which a battery of spatial tests, devised by Piaget, was administered to a group of white South African and Zulu children. The Zulu children were randomly drawn from Sub A to standard five, and the Whites were a random sample taken from standard one to standard five classes. The children were examined on those tests devised to investigate the child's conception of topological, projective and euclidean space. Each

test /...

test was composed of a number of subtests and the procedure followed was as close to that of Piaget as possible. The results obtained by the group of Whites were found to be significantly related to those obtained by Piaget's subjects. In addition, each child could be readily assigned to one of the stages defined by Piaget and Inhelder. On the other hand, an analysis of results obtained by the Zulu children revealed that these stages appeared to evolve later in this group than in the case of the White children. There are two points to be considered in an evaluation of this conclusion. The results are reported in terms of the children scoring above and below the mean score of the group. While from these scores it is possible to detect a significant increase with age in the number of children scoring above the mean, and a correlative decrease in the number of children scoring below the mean, it is not evident from the statistical procedure employed to what degree the children's results relate to clear-cut sequential stages of development. In the second place, although children of the same age were compared, several of the Zulu children were in Sub A and Sub B whereas the White South African children were initially drawn from standard one. Therefore, it is clear that children of the same age were compared but not necessarily drawn from the same school standard. The results may well be attributable to the possibility that environmental matching is not as adequate in the case of Zulu children as it is with the White group. Since Piaget stresses repeatedly that inadequacy of environmental stimulation results in a retardation in development, and hence a slowing down in the succession of stages, one would expect to find results in the direction of those of Cowley and Murray.

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The operant question, however, is whether results fall into the consecutive stages which Piaget defines. The results of Cowley and Murray in their present form do not lend themselves to deductions along these lines. However, the fact that the White children are in advance of the Zulu group may be considered as contributing adequately to Piaget's thesis of the importance of adequate environmental matching for conceptualization.

In concluding this brief section, it should be noted that study in this field is still very limited and that no adequate conclusion can be drawn in either direction. While these studies lend brief support to Piaget's contentions that topological relations are earlier detected by the child than euclidean properties, not one of the research projects has been reported in sufficient detail to deduce whether there are clearly defined stages of cognitive development in spatial conception. While these studies strongly support Piaget's contention that spatial conception undergoes a process of gradual development, and that spatial cognition at the adult level is not a ready-made product, it must still be determined whether the pre-history which Piaget defines, follows precisely the course that he has stipulated.

C. TIME CONCEPTION AND RELATED STUDIES.

The position which Piaget has adopted in the study of time conception is one that is so novel and in such contrast to the tenor of work already conducted in this field that particular consideration must be given to his point of view.

Prior to the publication of Piaget's "La Genese du Temps chez L'Enfant (1946) and even subsequent to this date, time studies were essentially

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devoted to the development of the child's understanding of time estimation and the development of time knowledge. Large scale studies (Ames [1946], Oakden [1922], Bradley [1947],) were conducted in an attempt to pin-point the precise ages at which the most fundamental facets of time knowledge emerged, and to establish a generalized pattern of time development characteristic of every child. While Piaget adopted a developmental approach, his interest lay fundamentally in the growth and emergence of time concepts. The development of time he related directly to maturation of underlying brain structures, and owing to this inception he considered that the concept of time in any child emerges in fixed and clear-cut sequential stages. The study of time knowledge, which can well be attributed to experience and training, is therefore clearly to be differentiated from the Piagetean approach.

According to Piaget, the child's earliest notion of time relates directly to those activities which he carries out in relation to his environment. In the earliest years, these activities serve as concrete anchorages to which the child's primitive ideas of time are linked. It is only with increasing age that these notions come to exist independently and as detached from supporting activity. The child's earliest concept of time, then, would relate to his feeding Schedule, and the activity which he carries out at successive intervals in relation to this schedule. Related to these events, notions of anticipation will occur, so that the child will often start to cry shortly preceding the usual feeding time or display characteristic oral movements. This muscular and motor activity is later supplemented by eye movements, all of which contribute to the sensori-motor activity inherent in

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what Piaget calls the first or sensori-motor stage. Already during the sensori-motor period the child's actions are internalized but as yet no co-ordination exists between them. On account of this lack of co-ordination during the sensori-motor period, and to a lesser extent in the periods intermediate between the sensori-motor and concrete operational stages, the child's idea of time is almost exclusively dependent upon the perceptual nature of the stimulus situation. To take only one example, one might consider the judgement made by the pre-operational child in the experiment devised by Piaget to test the child's ability to discriminate spatial from temporal intervals (Exp. 2 in our study). If the tester races a toy dog and rabbit in such a way that their running times are identical but the dog is brought to a halt beyond the rabbit, the pre-operational child will confidently assert that the dog has run for a longer time than the rabbit, and this reasoning is determined by the immediately structured perceptual field. The pre-operational child centres his entire attention on one aspect of the situation namely the final position of the dog and rabbit, and is unable to co-ordinate the various conditions preceding or contributing to the end result. It is characteristic of all the Piagetean time tests that they tap the child's capacity to differentiate the perceptual cues, which are spatial in orientation, from the temporal qualities of the situation. These latter qualities can be deduced only from a simultaneous consideration of various aspects of the test situation.

According to Piaget, however, it is only with advance in age and maturation that perceptual cues take a secondary place, and with increase in logical reasoning there goes a tendency to consider the situation as a whole, and no longer to centre

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attention exclusively on one aspect of the stimulus configuration. Moreover, whereas only rigid thought processes can emerge from perceptual cues, the child's reasoning becomes increasingly more mobile as the importance of these cues dimishes and co-ordination between internalized actions becomes increasingly predominant.

Thus Piaget's treatment of the development of time conceptualization in the child is, in fact, one further application of his general theory of concept formation. This development takes a course closely parallel to that followed by number and space concepts, and from Piaget's theory it is implicit that three broad stages of cognitive development which emerge during ontogenesis, evolve at approximately the same time in the life of the child in all three areas of cognition. It follows then, that a closely parallel pattern of development should be noted in space, time, and number conceptualization for one and the same child.

The question arises at this point whether, particularly in the development of time conceptualization, cognitive determinants can be evaluated as of prime importance to the exclusion of affective variables. It is, perhaps, the concept of time which has a closer relationship than either concepts of space or number to the personality of the child. To some extent, there is evidence for this point in the case of mentally disturbed patients. Distortions with regard to time are more frequently found in mental disorders or personality defects, than are distortions of space or number. The time sense has been found to alter in various mental disturbances, depersonalization, obsessional neurosis, depression and schizophrenia. If the development of time concepts

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as traced by Piaget is considered, one becomes less hesitant in understanding this phenomenon. According to Piaget time concepts, like concepts of number and space, emerge from the internalization of actions. There is little doubt that, in the case of time, these activities relate directly to experiences with individuals (mother or nurse) who constitute major poles in the development of his personality. It might therefore be expected that an adequate liaison between mother and infant during the earliest months, is of fundamental importance to an adequate concept of time. Disturbances in this early relationship might well lead to distortions in many areas of the child's functioning and certainly permeate the child's temporal field. As Piaget points out repeatedly, an adequately stimulating environment is fundamental to conceptualization in any area, but there seems to be a subtle difference in the character of this environment in the case of time concepts on the one hand, and space and number concepts on the other. As regards the latter concepts, an "adequate environment" may be considered as synonomous with an adequate "objective environment". The development of a concept of space and number demands an environment sufficiently enriched with objects such as toys, in relation to which he may conduct the activity which becomes internalized and later co-ordinated with other internalized actions. There is clearly a difference between this impersonal environment and the environment provided by the intimate personal relationship between mother and child which appears to be fundamental to an adequate development of time conception. It is important to note that Piaget has failed to take cognizance of this distinction.

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He has ignored subtle personality differences in determining the growth and development of time concepts, variables which, in the present study appear to have exercized considerable weight. It is possible that certain discrepancies between number, space, and time tests may be related to this point. This shall be considered later in the discussion of results. For the present, one can ask whether affective variables cannot camouflage, partially, the underlying pattern of clear-cut stages in cognitive development.

In considering these questions it is difficult to ward off hasty conclusions, but at no time should Piaget's original claims and intentions be overlooked. Since Piaget's interest lies predominantly in developmental epistemology, his research has been directed exclusively to the development of man's cognitive functioning.

It is difficult to criticize the procedure frequently adopted of dealing thoroughly with only one facet of a large behavioural field. Several areas lend themselves to a treatment of this nature, but particularly in the study of time conceptualization, the cognitive, and non-cognitive or affective aspects seem to be so interlaced, that one may question the validity of considering these contributing factors in isolation.

RELEVANT STUDIES ON TIME CONCEPTION.

Piaget's experimental approach, and the replication studies which have been undertaken in the area of time conception, must be distinguished from two alternative and concurrent trends in the field of research. Since Piaget has centred his attention primarily on the cognitive determinants of time, the tests which he has devised and the interpretations

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made, relate predominantly to this consideration. On the other hand, research is still undertaken following the lines of Ames (1946) and Bradley (1947), where experiments have been directed to the study of time knowledge in children. A second trend, and one that particularly in recent times has been gaining in impetus, relates to the effects which personality variables may exert on the individual's concept of time.

A fact which emerges from the survey of work conducted in this area is that the Piagetean approach to time development has not evoked particular interest. The practical difficulties involved have no doubt retarded research to some extent. Children must be tested individually, and the tests which have been devised are so long that a considerable time is required to administer even a small battery. In the second place, it seems that the effects of personality variables on time development have evoked more interest and independent research than considerations of cognitive determinants. Nevertheless several studies have been reported which are of immediate relevance to Piaget's theory.

Lovell and Slater (1960), following closely the procedure of Piaget, selected six time tests and administered these to a group of children aged five to nine years. These included tests which investigated the child's concept of age, his growth of awareness of subjective time, his ability to judge synchronous time intervals as equal, and tests which investigated the degree to which the child is able to differentiate spatial from temporal intervals. Results show that an increasing number of children at each progressive age group are able to solve time tests. This is in agreement with Piaget's hypothesis. It is unfortunate that the presentation of results as in many studies

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of cognition makes further interpretations and predictions impossible. It is axiomatic that the ability to solve any task, whatever its nature, will increase with age. The important question is what constitutes a significant increase from one age group to the next. Furthermore in this study, as in the case of nearly every other replication study, no statistical tool is employed, and assumptions are made from a brief perusal of recorded test scores. The authors, however, make several points of interest. From their study emerges the fact that some time tests are solved with greater facility than others by the group generally. Thus, on the tests devised to study the child's concept of age and the test of synchronous time intervals, there was a clear progress in the number of successful subjects with age. On the other hand, on the task devised to test the child's ability to differentiate spatial and temporal intervals, this clear-cut progress is less easily detected and it appears that even at the nine year level, a fair percentage of children still fail to give an adequate response. From these results it seems clear that a certain degree of variance between scores obtained on a battery of time tests will be found in the case of individual children. This finding which corresponds significantly with what was found in the present study, is difficult to reconcile with the Piagetean hypothesis. For if maturation of brain structures provides a general capacity which underlies conceptualization as a whole, how would Piaget account for the fact that one and the same child can solve certain logical premises and fail on others. As already indicated, the design and statistical procedure employed by Lovell and Slater prevent one from stating whether each child passes through a fixed sequence of stages, such as Piaget

proposes / ...

proposes, or to stipulate the degree of inconsistency which exists between a battery of time tests when administered to one and the same child.

Several points have emerged from early studies of Ames (1946), and Bradley (1947), which are of some relevance to Piaget's findings. Ames concluded from her study that critical ages could be defined, at which common time concepts emerged, and that these concepts came into use in a relatively uniform sequence from child to child, and at about the same relative stage in the life of every child. Ames attributed this phenomenon to maturation of brain structures which enables the child to master certain facets of time knowledge and exercise this relevantly. The tests, however, do not attempt to tap conceptual thought in the Piagetean sense, but take the form of questions which determine the extent of the child's time knowledge. In appraising the significance of this finding for Piaget's work, it must not be overlooked that the critical period of development which Ames sets at the six to seven year level corresponds also with the child's first year at school, during which particular attention is directed to the child's age, and a good deal of instruction is given on the most common notions of time. This may well be the principal explanation underlying the trend which Bradley (1947), Ames (1946), and Oakden and Sturt (1922) have found.

The studies on time conception that are of immediate relevance to Piaget's theory of cognition are so few, and the implications which follow from these so limited, that to draw conclusions on this basis would only be presumptuous. It appears particularly within recent years that Piaget's theory of time conception is being faced with a powerful challenge. More and more attempts are being made to

substantiate /...

substantiate that time conception is affectively bound, and if this is so, time cognition may not follow the fixed course Piaget has outlined for every child. But it is clear that this is not an "either-or" problem. It seems hardly feasible, that time is exclusively the product of affective variables on the one hand, or cognitive variables on the other. There is surely an interaction of both. The importance of research along the Piagetean lines can therefore not be stressed enough. If the cognitive aspect of time is to be studied, one can only hope for better Piagetean replication studies, better experimental control and better statistical analysis in the the near future.

D. MISCELLANEOUS STUDIES.

While we have primarily been concerned with research that has relevance to Piaget's work on the development of number, time and space concepts, there is one further line of study which has significant implications for the present hypotheses. This relates to the important work that has recently been conducted to investigate the nature of concept formation itself. Of specific interest are those projects which propose to determine whether concepts develop in the clear-cut sequential stages which Piaget hypothesizes, and whether these stages correspond to those which Piaget has found in his research.

One of the most recent contributions to our understanding of concept formation has been made by Bruner and his collaborators. (1964). On account of the modern techniques which these workers have used in their studies, and because their work enhances so much of what is fundamental to Piaget's research, it is necessary to consider the areas of overlap which have emerged and in addition to note interesting points of discrepancy.

Bruners's /...

Bruner's theory of concept formation is similar to Piaget's cognitive theory on a number of very fundamental points. Bruner's research has also been consequential upon his accepting a theory of clear-cut stages of development which emerge in a fixed and predetermined sequence in the life of every child. These stages correspond exactly to Piaget's four stages of sensori-motor, intuitive, concrete operational and formal operational development. In addition both authors state that at these four critical stages models of the world are created by actions, imagery, symbols and propositions respectively. Thus Bruner's description of the origin and nature of concepts, the internalization of actions, the gradual trend towards greater co-ordination between such internalized actions, and their tendency towards total reversibility, characterized by an intellect based on propositions, is in every respect analogous to that of Piaget. On the basis of this research Bruner also supports the contention that concepts develop sporadically and are immediately dependent upon an adequate maturation of underlying brain structures. This idea he embodies in the following statement (Bruner 1964 P 13) "The growth of intellect is not smoothly monotonic. Rather it moves forward in spurts and innovations".

One important point of discrepancy must, however, be noted between the two respective theories. While both theorists come to identical conclusions, Bruner tends to stress the learned aspects which determine concept formation, whereas Piaget tends to emphasize the innate factors fundamental to conceptualization. This is certainly not to say that either author gives theoretically less significance to environmental or constitutional factors, but in his interpretations, Piaget tends to stress the child's inherited potential whereas Bruner gives prominence

to / ...

to environmental determinants. The fact that Bruner, on the basis of techniques very different from those of Piaget, has traced a course of cognitive development that is in many ways analogous to that which Piaget puts forward, must be considered as constituting an important step towards the validation of Piaget's work.

In a recent book by Harvey, Hunt and Schroder (1961), dealing with the nature, origin and development of concepts, a number of important points have emerged in support of Piaget's contentions. These workers, on the basis of their research, conclude that concepts develop "saccadically" or in spurts and jumps, and that clear-cut stages can be differentiated in the course of the child's development. They also assert that concepts develop as a result of the interaction between the individual and the environment. The maturational determinants which constitute the genic counterpart are responsible for the initial placing of end points within which the child at any one stage is capable of functioning, while the training conditions stipulate the precise position of the child within these brackets. These workers, like Piaget and Bruner, also distinguish four stages of development, and while they do not attempt to link these stages to particular ages, they stipulate that conceptual development must proceed from thinking that is concrete or rigid to reasoning of a more abstract kind, and that until the former is mastered formal or abstract concepts based on propositions cannot emerge. There are further miscellaneous points of analogy:- concepts only emerge as a result of adequate co-ordination between internalized actions, and in addition, conceptual development is accompanied by progressive decentrations on the part of the child, until such time that the object and situation are

considered /...

considered as something independent and unrelated to the self.

Harvey and his collaborators have in addition focused specific attention on the effects which motivational variables exert on cognitive development, and in this respect their work takes a line of departure from that of Piaget. The affective variables which they consider, are those which relate particularly to the relationship between the subject and the experimenter, the rapport which exists between them, the results of increased motivation as a result of rewarding adequate behaviour, the effects of relating these tests to different criteria, encouragement of alternative solutions to problems and effects of enhancing the child's own self-esteem. These authors found that particularly after the second stage, these situational variables played an important role in determining the child's response. "It should be emphasized again", they state, "that stages of development interact with specific training conditions, so that functioning at one stage differs from functioning at another stage regardless of training, and functioning at a given stage differs according to the nature of the training method" (Harvey, Hunt and Schroder 1961 P. 156). These results are difficult to integrate with Piaget's view that motivation is inextricably bound with cognition, so that the one cannot be considered independently of the other.

A further support for Piaget's notion that concepts develop in stages comes from the work of Erwin (1960). She found that children who received training on tasks in which the underlying operations related to conceptual functioning beyond their stage of cognitive development, failed to solve a test parallel. Thus training had no obvious effects. Erwin accepted

this/...

this evidence as sufficient to show that the level of any child remained constant until further maturation took place, and that such stages followed one upon the other in a fixed and predetermined sequence.

One of the most important aspects of a concept according to a definition which Piaget formulated, is the growing ability in the child to consider various different points of view simultaneously, on the basis of which deductions can be made. This ability determines that the child is not confined to the present stimulus situation alone, but can co-ordinate various perspectives gained from the current as well as previous experiences. The work conducted by Lee Yudin (1959) using formal operational children, supports this latter contention. He found that twelve year olds were far less efficient than sixteen year olds in remembering previous guesses and so being able to check them with their current replies. In the case of older children, confirmation and infirmation was possible by virtue of the fact that previous replies could be related to more immediate ones. Thus the older children were able to co-ordinate a larger number of viewpoints than the younger subjects, a fact which both Piaget and Lee Yudin attribute to the level of greater maturity in the brain structures of the older child.

It appears, then, from the above studies, that particularly in recent times there has been weighty evidence in support of Piaget's theory of cognitive development. The evidence relates particularly to the intrinsic nature of concepts themselves and to the child's characteristic functioning at each developmental stage.

It is on this optimistic point that we turn to the present study.

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SECTION II.

V.a. Aim:-

The aim of the present study is to test two major hypotheses deriving from Jean Piaget's theory of cognitive development. These may be stated as follows:-

I. The child at the concrete operational stage functions at a consistent or homogeneous level within any one area of cognition, either of number, space or time.

II. A general level of cognitive functioning may be established at which each child responds on all three areas of number, space, and time. The level at which the child responds within one content area is, therefore, identical to the level of functioning which characterizes his cognition within other areas.

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b. Subjects:

The study was conducted on 60 primary school children, two of whom were eliminated during the course of testing owing to illness. The subjects were all girls in order to eliminate the sex variable, and the age range of the group extended from 5 yrs. 11 months to 9 yrs. 11 months. Since Piaget considers that the concrete operational stage emerges generally at the seven to eight year period, it was hoped by selecting children slightly below and above this age level, that the sample selected would constitute concrete operational children. The children were drawn from school standards Sub A to Standard two, twenty two from Sub A, fifteen from Sub B and standard one respectively, and a small group of eight from Standard two. Owing to the length of the tests, the study was confined to a small number of children and consequently an attempt was made to select as homogeneous a group as possible. Since Piaget's tests are predominantly tests of cognition, it was decided that the basis for homogeneity should be the level of mental maturity in each child. Teachers in the three Sub A classes, the two Sub B, two standard one and two standard two classes were therefore asked to select for the sample the most intelligent children in their class. Although the mental ages and IQ's were not available, the teachers asserted confidently that the children they had submitted were the most intellectually adept. It is of course realized that selection on this basis may not be perfectly reliable. The teachers stated, however, that in the case of the older children, where school tests had already been introduced, the average mark obtained by each of the subjects they submitted was frequently well over the 80% mark and in some cases average scores of over 90% were obtained.

Homogeneity/...

Homogeneity was to some extent established on the basis of another criterion also. Families of the children attending this school have a high socio-economic status. The principal stated that these children all came from exceptionally good and stimulating homes, and that in many cases, their fathers were professional men. From this it follows, that the quality of the environment which Piaget stresses is so fundamental for adequate conceptualization, is more or less stable and consistent for each child. It is again realized, and must be taken into account, that this second criterion for homogeneity is not absolutely reliable, but within small limits, the children in this study can be considered as a very select and homogeneous group.

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c. Experimental Procedure.

Each child in the sample of fifty eight subjects was tested individually and in order to maintain standardized conditions, the tests were administered by one tester throughout. Three independent sessions were required for each child. On the first of these the number tests were administered, on the second, the space tests and on the third, the time tests. The three sessions as administered to any one child were always completed within the period of one week to ensure, as far as possible, that the tests of number, space and time were tapping a stable level of maturation in the brain structures of the child. However no two batteris were ever administered to the child on the same day. It was found, generally, that the number and space tests were completed within a period of approximately 35 minutes each, whereas the time battery usually took within the region of 40 to 45 minutes to complete. Although each testing session was fairly long, it was found that the child's interest was maintained owing to the variety of tests in each battery. The testing on all three sessions was conducted in a school room set aside for this purpose, and the child sat at a table facing the tester.

In the first testing session, before the presentation of the number tests, the tester established rapport with the child by presenting her with a pencil and paper and encouraging her to draw a man as best she could. This drawing was admired and praised. On commencing each session, the following standard instructions were given:-

"Today we are going to play some nice games. I want you to play as best you can".

Thereafter, the five tests constituting the specific battery were administered, one at a time and in standard sequence.

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The method employed can best be defined as semi-structured. The Piagetean tests were followed as closely as possible and the material used in each test is that which Piaget describes. But in addition a set of standard questions was drawn up for each of the fifteen tests administered to ensure that each test was introduced and administered in a standard or uniform manner to every child. This was an attempt to reduce the difficulties, which we noted, are vested in an unstandardized test procedure such as Piaget has adopted. It must be realized that the tests, by their very nature are highly provocative, and questions were dealt with in as unbiased a way as possible. In the case of a shy child, prompting was also instituted if it was considered helpful. The auxiliary questions themselves were neither leading nor suggestive and frequently took the form of repetition of the original question.

The responses given by each child on a specific battery were recorded on a standard marking sheet, and on the basis of a scoring schedule devised for each test, a quantitative evaluation of each response was made.

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d. Test Material.

The tests used were those constructed and devised by Piaget and reported in his books on the conceptual development of number (1952), time (1955) and space (1956). Five tests were selected from each content area, constituting three batteries of five tests each. Thus fifteen Piagetean tests were administered to each child individually. While adopting the Piagetean tests in their original form, a set of standard questions was proposed to introduce each in order to circumvent, to some degree, the difficulties inherent in Piaget's original "clinical method". Since the tests are reported fully in Piaget's content books, it is proposed only to give a general outline of each test and in addition consider briefly the operations fundamental to the solution of each.

(i) Number tests.

The following Piagetean number tests were administered to the group:-

(a) provoked correspondence and equivalance of corresponding sets.
(b) the test of seriation, qualitative similarity and ordinal correspondence.
(c) ordination and cardination.
(d) the test of additive composition of classes.
(e) the test of additive composition of numbers and arithmetical relations of part to whole.

In the first of these tests, "provoked correspondence and equivalence of corresponding sets", the child must establish correspondence between two sets of objects which are quantitatively equal but differ with

respect / ...

respect to their spatial characteristics. Thus one set of articles is closely grouped together while the corresponding set is widely spaced, giving the superficial impression that the latter constitutes a larger number. The test determines whether the child can discard irrelevant perceptual cues, and rely instead on logical reasoning, which enables her to make a quantitative evaluation of both sets of objects between which the correspondence is to be found.

In the test of seriation, qualitative similarity, and ordinal correspondence, the child is presented with ten cardboard dolls which are identical in every other respect, but vary progressively in size. These the child is required to seriate. In the second section of the test the child is shown some small cardboard sticks which also vary progressively in length, and asked to give each doll its specific stick. Once this correspondence has been made, the sticks are grouped closely together so that each is no longer opposite the specific doll to which it corresponds. With the perceptual field thus distorted, the child must again make the adequate correspondence when the tester points to any specific doll or stick in either series. Finally, the child's ability to make an ordinal correspondence is determined by rearranging the order of the sticks and requiring the child to make the pertinent correspondence between any particular doll in the series and its stick. The ability to seriate, which, according to Piaget, constitutes one of the two operations fundamental to number conception, requires that the child responds, not to the global stimulus configuration, but distinguishes the criterion on the basis of which objects differ. Qualitative similarity requires two specific operations. The child must seriate both the dolls and sticks and

then /...

then employ the second operation fundamental to number conception, namely classification, whereby the two objects may be related on the basis of a property common to both. As Piaget has aptly stated "The solution of the final problem presupposes that each element is considered both as an element of a class and of a relationship, not alternatively and separately, as in the preceding system, but simultaneously forming one and the same operational whole, and this it will be remembered is our definition of number" (Piaget 1952 P.120). Ordinal correspondence, whereby the child relates the stick and doll when one series is disarranged, requires the child simultaneously to co-ordinate a number of discrepant aspects of the stimulus configuration. The object having a specific position in one series, must be related to an object which has the identical position in the other series. This task is again dependent on two logical operations, first of seriation and then of classification.

Ordination and cardination is tested by means of a series of ten sticks which vary progressively in size. The child is required to seriate these, much in the manner that the dolls were seriated. In addition, however, the subject is presented with a further nine sticks, different in colour from the original set. He is told that these have been "forgotten" and is required to insert them in the given series, in such a way, that every stick in the final series differs progressively, and in an identical ratio from the preceding one. The child's attention is drawn to the analogy between the completed pattern of sticks and a staircase, and he is required to state the number of stairs a doll has climbed, if it comes to a halt on any specific stair, the number of stairs behind it and the number of stairs still to be climbed. The latter test investigates the relations between ordination and cardination. Two operations are fundamental to the

insertion/...

insertion problem. The child must establish the relationship of one object to other sticks in the insertion series, and secondly he must relate this specific object simultaneously to two sticks in the initial series, so that it is smaller than the one which succeeds it in the series, and larger than the one which precedes it.

The test of additive composition of classes, requires that the child can reason that the whole is greater than the part, even though perceptual cues distort this judgement. The child is presented with ten glass beads, two of which are yellow and the remainder red. It is carefully explained to the child that all beads are glass, and furthermore the child is made to feel all the beads in turn and agree upon the nature of their fabric. He is then asked whether there are more yellow or glass beads. In order to frame the question in more intuitive terms, the child is also asked whether a necklace made with yellow beads is longer than that made of glass beads. A parallel problem is set with more familiar material, composed of a series of cut-out dolls, eight of which are girls, and the remaining two boys. The logical operation which underlies the solution of the task, involves additive components and graphically can be expressed as follows:- $B_1 + B_2 = A$ where A is equal to the total and B_1 and B_2 correspond to the constituent parts of A. The child must be able to reason that $B_1 = A - B_2$ and that subsequently $B \angle A$. Difficulty in tackling this problem appears to result from the inability to think simultaneously of the whole and the part. "The child apparently forgets the whole when he thinks of the part, and forgets the part when he thinks of the whole". (Piaget 1952 P. 171). The failure to consider the part and whole simultaneously induces the child to

consider/...

consider the part as an entity in its own right, and not as constituting a fraction of the whole. His judgement is thus predominantly determined by the perceptual characteristics of the stimulus configuration.

In the task of additive composition of numbers and arithmetical relations of part to whole, the operations inherent in adequate conceptualization are in many respects analogous to those in the immediately preceding test. Three parallel methods are used. In the first section, the child is required to state whether one set of beans presented in two piles of four and four, is equivalent to another, presented in two heaps of seven and one. In the second section, the tester places one pile of beans before the child, and another before a toy doll beside the child. The subject is required to equalize the number of beans in both piles by subtracting from one pile and adding to the other. In the final section, the child is required to divide into two a pile of beans put before him. This task again investigates whether conservation of the whole is maintained irrespective of the diverse grouping of its constituent parts. The task requires that the child can conserve the whole or maintain its invariance, independent of the perceptual structuring of the elements contributing to the whole.

It is clear that a basic trend is common to all these Piagetean tests. Each has been devised in such a way that certain well defined logical premises are tested, the solution of which is dependent on the child's ability to co-ordinate or relate several discrepant aspects of the situation and so deduce the adequate response. The perceptual cues are in each case played off against the conceptual criteria. Only the child at the concrete operational stage can select the pertinent cues to which to respond.

ii. / ...

(ii) Space Tests.

Five tests were selected from Piaget's book on the development of spatial conception (1958). These are as follows.

(A) the test of perceptual and representational space.
(B) the treatment of elementary spatial relationships in drawing.
(C) linear and circular order.
(D) the test of projective lines and perspective.
(E) the test of affinitive transformations of the rhombus and the conservation of parallels.

The first space test administered to each child, is that of "perceptual and representational space". In the present study, thirteen euclidean and topological shapes were selected from the sample (1958 P. 19) which Piaget uses in his studies, and these were represented by carbon cut-outs. Shapes were handed to the child one by one under the table in order to prevent him from actually seeing the figures. On the basis of feeling the given objects, the subject must make the correct identification on a sheet placed before him on which the corresponding figures are drawn. This task clearly elucidates Piaget's contentions that operations are internalized actions which are co-ordinated in such a way that reversible or mobile though processes result. The solution of this problem necessitates transfer of a tactile kinesthetic cue into an image of the object so that the child can correctly identify the figure on the chart before him. Unless the object is adequately explored, the internalized actions cannot be co-ordinated and hence the image of the object is

incomplete/...

incomplete or distorted.

In the second spatial test selected, that of "elementary spatial relationships, "the child is presented with eleven cards, on each of which a figure has been drawn. These are identical to those Piaget has used, and which are represented in his book of spatial conception (1958 P.54). These figures are such that they embody both euclidean and topological relations. The child is instructed to draw these figures one by one, each on a clean sheet of standard size. According to Piaget, an adequate representation of the figure is dependent upon the child's ability to create an undistorted and complete image of the figure. This image is the final resultant of a number of perceptual activities which are internalized and co-ordinated in such a way that a complete image is evolved. This Piaget has expressed as follows:-
"We may therefore take it, that the problem is not one which depends upon motor ability, but rather on the method of composition itself, in other words, on the type of regularity mechanism which will result in the construction of a shape on the basis of elements isolated from the original pattern." (Piaget 1958 p.66).

The third test of "linear and circular order" is divided into a number of subsections as follows:-
The first task requires the child to thread seven beads onto a needle so that the pattern corresponds exactly with that on a needle which the tester places before the child. In the second subsection, the task is similar in nature but in this instance, the child must construct an order which is the reverse of that on the needle before him. In the third task the child is presented with seven beads threaded on a plastic and flexible cord. The cord is tied in the manner of a circular necklace. The child is instructed to make her own necklace, but to thread the beads on the needle used in the previous subsection, the order to be identical to that on the circular

/necklace...

necklace. Finally, the child is presented with a plastic cord on which seven beads are threaded but which is twisted in a figure of eight. The child is required to construct an identical order again using the needle. The representation of linear and circular order is immediately dependent on an image, constructed on the basis of internalized and co-ordinated perceptual activity. In the first subsection the proximity subsisting between separate elements can be perceived intuitively, and is not dependent on operational thought to the extent that this is fundamental to subsections two, three and four. In the case of a reproduction of circular order, the figure of eight, or a representation of reversed linear order, the child can no longer rely on an identical perceptual configuration between the copy and the model at hand. Piaget explains that when order is correctly established each element in that ordered sequence must be separated from the adjacent members momentarily. Hereafter reassembly again occurs. Purely the perceptual stimulus in itself is inflexible and rigid, and on this basis alone separation and a process of reassembly could not occur. It is only when the child is capable of forming a mental image, which can be transposed and mobilized, that the child is capable of representation.

The fourth spatial task, selected from the battery of Piagetean space tests, is that which requires the construction of a projective straight line. This task is again constituted of four subsections. In the first instance, the child is presented with ten matchsticks placed in plasticine stands in order that they stand upright as posts. The child is required to place these "posts" in a straight line parallel to the straight side of a rectangular table. In the second subsection the task required of the child is a slight variation of the former one. In this case the child must construct

posts /...

posts between two end poles, placed midway on adjacent sides of the table. The constructed line would then form a triangle with the two sides of the table.

In the third subsection the child is presented with a cardboard round. One post is placed at one point on the circumference and another at another point. The child is required to construct a straight line between these posts, so that they form a chord of the table. Finally, ten posts are set up by the tester on the cardboard in an irregular line. The child is required to shift the posts in such a way that the line which they represent is straight. In the case of subsections two, three and four, the child is required after each construction to find the point at which he can best state whether the line is in fact straight or not. This is an additional test of perspective. If the correct point is detected the child is allowed to make specific reconstructions and so correct his performance.

The operations which are fundamental to adequate perspective are analogous to those which underly the aforementioned tests. In order that the child can construct a line in perspective, he must be able to discriminate one viewpoint from a large number of irrelevant viewpoints. It is necessary that he co-ordinates one viewpoint represented mentally with others. In the case of the pre-operational child, the line that is constructed will be heavily determined by the perceptual cues, and the child relies implicitly on cues provided by the background stimulus.

The final spatial test, specifically designed to illustrate euclidean spatial relations, constitutes what Piaget has called the "lazy tongs experiment". The material for this test is provided by any object, gadget or tool, which produces transformations of the rhombus. The requirement for this gadget is a series of crossed rods with ends joined in pairs, forming a series of

rhombuses. With the apparatus closed no rhombuses are discernible, but as it opens out it forms a series of rhombuses, narrow at first and becoming wider as the handles are drawn wider apart. In the present study this object was provided by an ordinary pot-stand, which expands when pulled out and folds when pressure is exerted on the handles. The tester expanded the object to its limit and then asked the child to note carefully what happened when pressure was exerted on the two outside handles. Three illustrations were given to every subject, with the tester pressing the handles closer together each time. The child is asked to note what happens to the "holes" and on giving the reply that these get bigger, is required to show how a "hole" would look with added exertion on the handles. This he does by drawing the shape on a standard piece of paper. Three further figures must be constructed by him, in each case showing the transformation that the rhombuses undergo with increased pressure on the handles. The solution of this task is perhaps the clearest illustration of Piaget's contention that operational reasoning is fundamental to an adequate conceptualization of space. In order that the child can represent the rhombus through its various transformations, illustrating the parallelism of the sides and conservation of their length with specific change in the size of the angles which they subtend, he must be able to represent these various aspects mentally, and in addition co-ordinate or interrelate these diverse qualities of the figure. The child who relies purely on the static qualities of the perceptual stimulus, and is unable to co-ordinate internalized images of its divergent aspects, must fail to represent this object through various stages of its transformation.

(iii) Time Tests.

The Piagetean time tests have been devised predominantly with one view in mind. This has been the

presentation / ...

presentation of both spatial and temporal cues, in an attempt to determine the child's ability to dissociate one set of cues from the other. While the spatial cues relate to the perceptual characteristics of the situation, the temporal cues can be deduced only from a simultaneous consideration of several pertinent aspects of the problem. This latter ability is fundamental to adequate logical reasoning, and on this account, Piaget claims that his tests serve as an adequate tool to differentiate the operational from the pre-operational child.

The five Piagetean time tests are a selection made from each of the three major sections in Piaget's book on the development of time concepts (1955), that of "Elementary Operations", "Physical time", and "Subjective time". The tests used were the following:

(A) the test of "Duration of Intervals".
(B) the test of "Synchronous Time Intervals"
(C & D) two tests devised to investigate the child's concept of age.
(E) a test which taps the child's ability to estimate the duration of his own actions.

In the first test the child is required to watch the tester siphoning water from a tall thin measuring-cylinder into a short wide beaker. The measuring-cylinder and beaker are of equal volume. Each container is marked with ten lines in such a way that the volume between any two marks on the measuring-cylinder corresponds to that between any two points on the flask. The child is required to state whether the time taken to fill any specific volume in the flask, corresponds with that taken to fill an identical or an asynchronous volume on the measuring-cylinder. In section two of the test, the child is required to order a series of cards (D_1), on which the flask and measuring-cylinder are

depicted/...

depicted. The series shows the varying levels of liquid as the water sinks in the one container and rises in the other. In series D_2, which the child must also order, the corresponding flask and cylinder are separated by cutting each D_1 card in two. The cards are shuffled and the child is required to place the corresponding cards in pairs again. Both sections of the test have been specifically devised to tap the child's ability to discriminate spatial perceptual cues from temporal cues which are dependent on operational reasoning. It is necessary that the correct response is deduced from simultaneous consideration of various aspects of the situation. The child must take into account that the water starts flowing simultaneously in both flasks, and that the flow halts simultaneously. He must consider the length of each container in relation to its width and in turn relate these idiosyncrasies to differences in the speed with which water sinks in the one and rises in the other. This is only possible in the operational child.

In section two where only static levels can obviously be presented, the characteristic reasoning of the operational child is again that deduced from a simultaneous consideration of a number of aspects. It appears that two operations are basic to this task. In the first instance the child must relate a given volume in the one flask to an identical volume in the second, irrespective of irrational perceptual cues. In the second place it is necessary that these volumes are correlated with synchronous time intervals. Both these operations are dependent on the child's ability to interrelate various aspects of the stimulus situation and discard irrelevant spatial cues.

The second time test is similar to the first in that it attempts to determine whether the child can

discriminate/...

discriminate perceptual from conceptual cues. This test which for the present purpose we may designate as the "dog and rabbit experiment", is a measure of the child's ability to conceptualise physical time. Physical time relates predominantly to some event in which the child is not personally involved. In the "dog and rabbit experiment", the toy dog is placed a few centimetres beyond the rabbit on a table, and the child's attention is drawn to the fact that the two objects are to "have a race". The tester propels the objects, and brings them to a halt simultaneously. However the dog is accelerated at greater speed than the rabbit, and hence it's final placement beyond that of the second object. The child is questioned as to the simultaneity of the starting and stopping times of the two objects, and in addition several questions are framed to determine whether the child understands that the running times of both objects are identical, irrespective of the false cues provided by the perceptual quality of the stimulus. The child at the concrete operational stage must arrive at the adequate response through simultaneous co-ordination of a variety of aspects inherent in the situation, the simultaneity in the starting and stopping of the objects, and the greater speed of the one relative to the other. The pre-operational child relies on the perceptual aspects of the situation and hence the final placement of the two objects. "Further in space" is synonymous for "longer in time". Piaget states that the following thought processes are characteristic of the pre-operational child:- "When one goes faster, one goes further (spatially) and time is directly proportional to the distance covered. In the second place when one goes faster, one takes more time because one goes a longer way". (Piaget 1955 p. 144).

Three / ...

Three tests have been selected from the section which relates to subjective time, two which investigate the child's concept of age, and a test which determines the child's ability to estimate the duration of his own actions.

The first of the "age" tests consists of a series of questions, the general trend of which is to determine whether age can be related to birth order, and further whether the child understands the principle of conservation of birth order and hence of age relations, even if these considerations are related to future time. The concept of age is also dependent upon a number of fundamental operations which emerge independently as the child matures. In the case of the pre-operational child, it is the perceptual cue which determines his reasoning. Thus for the young child, increasing age is directly related to size increase. In the case of the operational child, however, the concept of age requires co-ordination between two aspects, the occurrence of any particular event, and the time interval between that event and the present time.

The operations basic to subtest four are in many respects analogous to those fundamental to test three. The test is also devised to determine the child's concept of age, but whereas the third test investigated this concept as related to the self and other individuals, subtest four is devised to tap the child's ability to make deductions about the age of independent and visually depicted objects in his environment. The test is constructed of four subsections. In the first of these the child is shown a card on which two trees are drawn. The one, an elm tree, is short and broad, the other which is designated as an oak tree, is tall and slender. The child is asked to state whether he considers the

two/ ...

two trees as identical in age, or whether he considers the one younger and the other older. In the second subsection the child is presented with a series of ten cards depicting apple trees and another series of ten cards representing pear trees. In each series the trees vary progressively in size, but are drawn in such a way that the younger series (pear trees) are larger than the corresponding apple trees from the third year following. The child is then required to state which series is older or younger, the oldest and the youngest trees of all, the relations between any apple and pear tree at a specific synchronous age level, and the relation between two trees in the independent series at asynchronous age levels. In the final subsection of this test, the child is required to state whether two trees identical in size are equal in age or not. The one tree, however, has three fruits whereas the other has eight.

It is clear that in all subsections of this test perceptual cues are highly compelling and present the most obvious characteristics of the stimulus configuration. It is only the operational child who demands other criteria, such as date of planting, or "the number of rings in the trunk of the tree", before making the specific judgement. It is interesting to note that while the nature of these criteria are indicative of learning, Piaget's theory assumes that a pertinent level of maturation must be reached before this knowledge is retained and adaptively employed when the situation demands.

The final time test is that which determines the child's ability to estimate the duration of his own actions. The child is required to draw a set of lines, one quickly, the other slowly, over identical time periods. On completion of this task, the child is required to state whether the durations taken to accomplish the tasks are identical or whether one set

of / ...

of lines has taken longer to draw than the other. In the case of the pre-operational child, perceptual cues presented by the difference in the length of the drawn lines are fundamental in determining the child's judgement. Length of the lines would be directly proportionate to duration of the drawing time. The operational child on the other hand is characterized by the ability to relate speed of drawing to length of drawn line. He thus deduces that duration of drawing time is in fact independent of the length of the line. This simultaneous co-ordination of several aspects of the situation is the rudiment of conceptual thought.

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E. Experimental Procedure.

Owing to the length of the section dealing with the Piagetean tests used in this project, it is proposed to outline again at this point, the experimental procedure employed before discussing the results obtained in the study.

Each child in the sample of fifty eight subjects was tested individually and in order to maintain standardized conditions, the tests were administered by one tester throughout. Three independent sessions were required for each child. On the first of these the number tests were administered, on the second, the space tests and on the third the time tests. The three sessions as administered to any one child were always completed within the period of one week to ensure as far as possible that the tests of number, space and time were tapping a stable level of maturation in the brain structures of the child. However, no two batteries were every administered to the child on the same day. It was found generally that the number and space tests were completed within a period of approximately 35 minutes each, whereas the time battery usually took within the region of 40 to 45 minutes to complete. Although each testing session was fairly long, it was found that the child's interest was maintained owing to the variety of tests in each battery. The testing on all three sessions was conducted in a school room set aside for this purpose and the child sat at a table facing the tester.

In the first testing session, before the presentation of the number tests, the tester established rapport with the child by presenting her with a pencil and paper and encouraging her to draw a man as best she could. This drawing was admired and praised. On

commencing/...

commencing each session the following standard instructions were given:-

"Today we are going to play some nice games. I want you to play as best you can".

Thereafter the five tests constituting the specific battery were administered, one at a time, and in standard sequence.

The method employed can best be defined as semi-structured. The Piagetean tests were followed as closely as possible and the material used in each test is that which Piaget describes. But in addition a set of standard questions was drawn up for each of the fifteen tests administered to ensure that each test was introduced and administered in a standard or uniform manner to every child. This was an attempt to reduce the difficulties which, we noted, are vested in an unstandardized test procedure such as Piaget has adopted. It must be realized that the tests, by their very nature, are highly provocative and questions were dealt with in as unbiased a way as possible. In the case of the shy child, prompting was also instituted if it was considered helpful. The auxiliary questions themselves were neither leading nor suggestive and frequently took the form of repetition of the original question.

The responses given by each child on a specific battery were recorded on a standard marking sheet, and on the basis of a scoring schedule devised for each test, a quantitative evaluation of each response was made.

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VI. RESULTS AND DISCUSSION OF RESULTS.

a. Introduction.

Fifteen subtests were administered to each child, five each of space, number and time. In contrast to Piaget's method, the tests were not marked in terms of stages, but scored according to a quantitative scale devised for this purpose. Since this scale allows fine discriminations, it is considered more reliable than assigning each score directly to a particular stage. The difficulties of this latter method have already been discussed, but it might be recalled that the prime criticism against this procedure is the fact that one is frequently uncertain as to the precise stage which defines the response on the basis of the scoring criteria which Piaget presents.

The child's quantitative score on each of the fifteen subtests was calculated. These may be seen in Table I a, b, c. The hypothesis under consideration requires that the intra-test variability among five subtests comprising a battery be calculated for each child, in addition to the inter-test variability among the three content areas. From this computation it can be deduced to what extent the child's level of thinking remains constant in any one area of cognition, as well as the degree of stability among the three content areas of number, space and time.

With this view in mind, the raw scores for all fifty eight subjects obtained on space, time, and number tests were converted to standard "T" scores. The calculation of standard scores was necessitated by the fact that a particular quantitative score on one Piagetean subtest does not necessarily have the same connotation as the identical score on another subtest. Since the standard score is expressed in units of the standard deviation it follows that scores reduced in this way may readily be compared.

Tables / ...

Tables 2, 3 and 4 show the standard scores obtained by the 58 subjects on the number, space, and time tests respectively.

Statistical analysis provided a number of unforeseen difficulties. Whereas Piaget suggests implicitly that at any particular stage of development the child will, within limits of experimental error, respond stably on all tests devised to tap development at this level, our results show that it is difficult to generalize over the subtest scores obtained by any one subject. This applies equally to results recorded on the number, space, and time tests. Since the results obtained by a particular child in any one content area do not permit us to allocate the subject to a specific category of cognitive functioning, it becomes difficult if not impossible, to make a direct comparison between the child's performance on the number, space and time tests. Another approach had therefore to be taken. From Piaget's theory it follows that a high intra-test coefficient of reliability will be found between the subtests comprising the battery of any major concept test. Since any one battery of subtests has been devised to tap a particular level of conceptual development in the child, the score obtained by the subject on any one of these subtests should be an extremely reliable pointer to his score on another subtest. The Kendall Coefficient of Concordance W, calculated by formula 9.15 as given by Siegel (1956 P.233), has been particularly useful in the present study, for it serves as a measure of the relationship between several rankings obtained by a subject on N variables. Whereas the Spearman Rank Correlation allows for a correlation between only two variables at a time, Kendalls' Coefficient of Concordance W, serves as a helpful shortcut to determine the association between any number of variables. If a significant association exists between the five subtest scores for each child, we might expect this association to be

reflected/...

reflected in the congruence between the ranks assigned to the subject's scores on those tests. Consequently subject A would be ranked as obtaining the highest score in the group on each of the five subtests constituting any one battery. Subject B would be ranked as obtaining the second highest score on each of the subtests, and subject N would be ranked as obtaining the Nth highest scores on each of the given tests. This ideal model is obviously never obtained within the framework of experimental procedure, but it is possible to determine whether the association between the sets of ranks is statistically significant. In order to determine the degree of significance, Kendall's Coefficient of Concordance is computed. Provided that this coefficient is significant, we can predict that the five subtests tap a fairly homogeneous level of functioning in each child in that group, and that a significant degree of intra-test reliability exists between the tests, when administered to the specific group in question.

The formula for Kendall's Coefficient of Concordance W is taken directly from Siegel (1956) and is as follows:-

$$W = \frac{S}{\frac{1}{12} K^2 (N^3 - N)}$$

where S = sum of the squares of the observed deviations from the mean, R_j (or sum of ranks)

K = number of variables (tests)

N = number of individuals ranked

$\frac{1}{12} K^2 (N^3 - N)$ = maximum possible sum of the squared deviations i.e. the sum S which would occur with perfect agreement among the K rankings.

For the purpose of the present study, this statistical tool is also of particular value, for it provides for tied rankings. Kendall has computed

an / ...

an additional formula to counteract the depressing effects of tied ranks on the value of W. The correction factor is provided by the formula.

$$T = \frac{\sum (t^3 - t)}{12}$$

Where t = number of observations in a group tied for a given rank.

$\sum$ = directs one to sum all groups of ties within any one of the K rankings (Siegel P.234).

Taking into account the correction factor, the coefficient of concordance becomes

$$W = \frac{S}{\frac{1}{12} K^2 (N^3 - N) - K \sum_T T}$$

Where $\sum_T T$ directs one to sum the values of T for all K rankings (Siegel P.234).

In addition, Kendall has provided a formula to test the significance of any observed value of W by determining the probability associated with the occurrence under Ho (Null hypothesis) of any value as large as an observed value of W.

This formula is as follows:-

$$x^2 = K (N - 1) W \quad \text{(Formula 9.18)}$$

with degrees of freedom = N - 1.

Reference to Table C (Siegel P.249), shows the probability of accepting or rejecting the null hypothesis associated with so large a value of x^2, as computed by formula 9.18. This formula enables us directly to reject or accept the null hypothesis that the sets of rankings obtained on the N variables are independent. If the null hypothesis is accepted, this implies that the different subtests are tapping independent measures.

If / ...

If the null hypothesis is rejected, the reverse is true, that a significant association exists between the tests, and the concordance found cannot be attributed to chance factors alone.

A slightly different procedure has been introduced for testing the null hypothesis when N $\angle$ 7. For small groups of subjects, from three to seven, the null hypothesis may be tested directly by reference to table R (Siegel P.286). This shows the critical values of S for W's significant at the .05 and .01 levels of confidence.

Before presenting and discussing the results, however, certain aspects of the statistical method used and its implications must be noted.

The rankings which were made in computing the coefficient of concordance between subtests for any group, were based on the child's standard scores. This was found to yield slightly more accurate results than rankings based on raw scores.

Secondly it must be taken into account that this method only allows us to make predictions about the reliability of a battery of subtests as applied to a group of children. In conducting the statistical analysis we have composed groups in different ways. In the first instance children have been grouped according to school standards. Groups one to four correspond to school standards Sub A to Standard two. In the second instance children have been divided into groups on the basis of age. The age range from six to nine years was divided into six monthly intervals, the children falling within any one age interval, constituting a specific group. Six groups have been delineated using this criterion. For purposes of the present study the former groups will be referred to as the S groups and the latter as the A groups. While both A and S groups are naturally made up of the same children, it shall be attempted to note whether significant differences

in / ...

in W values are obtained between the A groups (divided on the basis of age), and the S groups (divided on the basis of school standard). There is little doubt that the subgroups constituting the A and S groups respectively overlap to some degree, that most of the six year olds will be in Sub A, the seven year olds in Sub B and so on. However, we felt it necessary in view of Piaget's theory of critical stages, to make finer age discriminations which could relate to specifically different levels of maturation. It can be seen from Table 6, that within each S group there is wide variance in the age range. In the first S group, for example, there are subjects who are barely six years old at the one extreme and over seven at the other. These children constitute the same S group but different A groups. There is, therfore, a fairly significant discrepancy in the constitution of the A groups on the one hand and the S groups on the other.

A third point which must be considered before the actual presentation of results is that we omitted to compute concordance values for number subtest one (conservation of continuous quantities), and time subtest three (age concept test one). From the raw score tables (Tables 1 a, b, c.) there is little doubt that the sample as a whole appears to be functioning at a level well in advance of the level of these tests. A computation of standard scores for the sample on these two subtests would have been strongly subject to the "ceiling effect", and so did not warrant an analysis of this kind.

For each of the ten groups, values of W were computed for space, time, and number tests respectively. This procedure gives insight into the relationship between the subtests in any one content area for a particular group, and in addition, by comparing the values of W obtained by a specific group in the different content areas it is hoped that further predictions can be made as to the relationship between one content area

and / ...

and another.

It is proposed at this point to give a general outlay of the tables which follow, in order to make these more comprehensible:-

Table I shows the raw scores obtained by the 58 subjects on the number, space and time tests respectively:-

Tables 2, 3 and 4, present the converted standard "T" scores for the sample on the number, space and time tests respectively.

Table 5 shows the number of children at each age level in the A groups, and Table 6 presents the number of children in each of the S groups, and the mean age of the group.

Table 7 shows the "W Scores" obtained by the Six A groups on the number, space and time tests respectively.

Table 8 presents the "W" values for the S groups.

Table 9 represents the values of Chi square (χ^2) and the corresponding levels of significance on the number, space and time tests, for S groups one to four, and Table 10, presents these values, as computed for the six A groups.

Finally Table 11 presents the percentage of children in each of the four S groups at "Stage" three, two and one, on each of the five number subtests, and Tables 12 and 13 present a similar computation on the space and time tests for each of the S groups.

In the appendices a detailed scoring schedule is presented, on the basis of which scores were assigned to each child on the individual tests comprising the

number / ...

number, space, and time batteries. Reference to this schedule makes results in the immediately following section more comprehensible.

A further set of tables will also be presented in the appendices, in addition to a series of graphs representative of individual protocols on the number, space, and time tests. The general outlay of these tables and graphs will be given later.

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TABLE I.

TABLE SHOWING RAW SCORES OBTAINED BY 58 SUBJECTS ON NUMBER, SPACE AND TIME TESTS.

	(a) Number Tests.					(b) Space Tests.					(c) Time Tests.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Maximum Score on Test.	7	10	12	8	7	13	33	8	12	5	15	15	10	**25**	9
Std I group															
1. M.W.	7	10	7	8	7	12	28	6	11	5	13	13	10	23	6
2. A.B.	7	8	6	2	7	10	29	7	1	5	11	13	10	17	9
3. D.A.	7	7	6	1	4	11	30	5	8	3	10	8	10	18	9
4. P.C.	7	6	10	1	7	11	29	8	4	2	13	15	10	18	9
5. D.H.	7	9	8	0	7	11	28	8	12	1	11	10	10	23	9
6. C.D.	7	8	9	1	6	9	29	8	11	4	5	4	9	21	9
7. J.S.	6	8	10	3	7	10	29	8	1	2	9	8	9	16	9
8. G.M.	7	6	7	3	6	11	30	8	7	2	7	10	9	23	9
9. K. vd M.	6	7	8	4	6	9	29	8	9	4	13	12	10	22	9
10. J.v.A.	7	4	9	1	4	11	26	8	4	5	9	0	10	14	3
11. E.S.	6	9	10	3	6	10	26	7	4	4	12	5	10	20	9
12. G.G.	7	10	9	4	7	10	30	8	5	4	12	13	10	10	9
13. L.M.	6	8	12	1	4	11	27	8	6	4	11	9	10	14	9
14. M.L.	7	7	10	3	7	8	25	7	3	1	9	10	10	15	9
Sub A group															
15. M.B.	7	4	9	1	4	10	19	7	8	3	10	6	10	13	6
16. C.H.	7	7	8	8	4	10	23	7	3	4	11	8	10	10	3
17. E.D.	4	5	6	7	6	11	20	8	5	1	3	8	10	20	9
18. G.M.	7	6	8	2	5	10	23	8	8	2	5	2	10	15	3
19. P.A.	7	5	7	2	6	12	20	8	3	3	12	8	6	11	3
20. J.M.	6	8	6	1	4	12	23	3	2	3	5	8	10	11	3
21. H.B.	7	9	7	2	2	13	23	8	2	3	8	15	10	14	6
22. G.Q.	7	7	8	4	3	13	28	8	12	4	5	0	6	18	6
23. R.M.	2	6	9	2	4	9	28	8	4	3	8	4	10	19	6
24. I.F.	7	9	9	1	3	13	27	5	11	4	7	0	10	4	6
25. M.G.	7	6	5	2	3	12	25	8	4	1	6	8	10	14	6
26. A.J.	7	8	10	2	7	12	27	8	4	3	7	11	10	12	9
27. A.G.	7	10	6	4	7	12	27	5	5	3	10	8	6	10	6
28. H.S.	7	5	6	8	4	7	21	8	5	1	8	0	10	13	6
29. A.C.	7	5	6	1	4	11	21	6	9	2	5	7	9	10	6
30. E.F.	6	4	7	2	4	9	22	6	8	4	3	1	7	12	3
31. P.D.	6	3	5	1	5	8	24	8	4	2	9	8	10	20	9

32. C.B.	7	7	4	1	4	9	23	8	9	5	13	13	10	16	9
33. S.B.	6	4	12	1	2	9	30	4	4	2	4	1	8	13	3
34. N.A.	7	7	7	1	4	6	26	8	9	4	9	6	10	11	3
35. K.S.	7	5	4	4	4	12	25	6	1	3	4	13	10	12	9
36. M.W.	6	5	9	3	4	12	22	6	1	2	10	6	10	20	6
Sub B Group															
37. R.S.	7	6	8	3	7	9	29	8	7	5	9	14	10	24	9
38. M.T.	7	9	10	8	7	9	28	7	10	5	15	15	10	17	9
39. K.R.	7	10	8	6	7	10	29	8	11	4	14	11	10	24	9
40. B.G.	6	7	9	3	7	10	26	8	3	5	3	8	10	11	9
41. S.G.	7	6	11	2	4	12	32	8	4	4	9	4	10	21	9
42. F.T.	7	6	8	1	7	9	30	6	7	3	13	3	10	19	6
43. W.H.	7	7	11	2	7	12	30	8	5	4	10	9	10	20	6
44. S.P.	7	4	6	4	4	9	21	6	0	4	9	9	10	15	6
45. A.S.	7	8	8	4	7	10	29	8	5	2	11	12	10	18	3
46. B.J.	7	8	5	2	7	11	21	6	9	3	3	7	10	6	6
47. L.S.	6	8	10	2	4	11	22	6	4	4	6	2	10	17	6
48. M.G.	7	6	8	3	7	10	23	7	1	1	12	10	10	19	6
49. G.S.	7	7	9	4	6	11	26	6	8	3	13	6	10	23	9
50. P.G.	6	9	10	1	7	11	30	8	11	4	12	14	6	17	6
Std. II Group															
51. E.B.	7	10	12	8	7	13	29	8	12	5	13	10	10	21	9
52. A.G.	7	10	10	8	7	13	29	7	9	4	14	9	10	11	6
53. H.P.	7	10	11	8	7	13	30	8	9	4	13	15	10	22	9
54. S.B.	6	6	9	7	7	10	29	6	3	3	13	1	10	15	9
55. F. McD.	6	10	12	4	7	11	29	8	11	3	7	10	10	17	9
56. L.L.	7	10	12	8	7	12	29	8	12	5	14	6	10	25	9
57. T.J.	7	7	12	4	7	10	31	6	10	3	9	1	10	20	9
58. A.F.	7	9	8	8	7	11	30	7	9	4	12	10	10	23	9
TOTAL		415	486	195	322	613	1534	414	367	190	541	457		957	411
Mean Score to first Decimal Place		7.1	8.4	3.4	5.6	10.6	26.4	7.1	6.3	3.3	9.3	7.9		16.4	7.08

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TABLE 2.

TABLE SHOWING STANDARD SCORES OBTAINED BY 58 SUBJECTS ON NUMBER TESTS.

Subjects	2	3	4	5
1.	1.52	- .66	1.91	.87
2.	.47	-1.14	- .58	.87
3.	- .05	-1.14	-1.00	-1.0
4.	- .57	.76	-1.00	.87
5.	1.00	- .19	-1.41	.87
6.	.47	.28	-1.00	.25
7.	.47	.76	- .16	.87
8.	- .57	- .66	- .16	.25
9.	- .05	- .19	.25	.25
10.	-1.63	.28	-1.00	-1.0
11.	1.00	.76	- .16	.25
12.	1.52	.28	.25	.87
13.	.47	1.71	-1.00	-1.0
14.	- .05	.76	- .16	.87
15.	-1.63	.28	-1.00	-1.0
16.	- .05	- .19	1.91	-1.0
17.	-1.10	-1.14	1.5	.25
18.	- .57	- .19	- .58	- .37
19.	-1.10	- .66	- .58	.25
20.	.47	-1.14	-1.00	-1.0
21.	1.00	- .66	- .58	-2.25
22.	- .05	- .19	.25	-1.62
23.	- .57	+ .28	- .58	-1.0
24.	1.00	.28	-1.0	-1.62
25.	- .57	-1.61	- .58	-1.62
26.	.47	.76	- .58	.87
27.	1.52	-1.14	.25	.87
28.	-1.10	-1.14	1.91	-1.0
29.	-1.10	-1.14	-1.00	-1.0
30.	-1.63	- .66	- .58	-1.0
31.	-2.15	-1.61	-1.00	- .37
32.	- .05	-2.09	-1.00	-1.0
33.	-1.63	1.71	-1.00	-2.25
34.	- .05	- .66	-1.00	-1.0
35.	-1.10	-2.09	.25	-1.0
36.	-1.10	.28	- .16	-1.0

37.	- .57	- .19	- .16	.87
38.	1.00	.76	1.91	.87
39.	1.52	- .19	1.08	.87
40.	- .05	.28	- .16	.87
41.	- .57	1.23	- .58	-1.0
42.	- .57	- .19	-1.0	.87
43.	- .05	1.23	- .58	.87
44.	-1.63	-1.14	.25	-1.0
45.	.47	- .19	.25	.87
46.	.47	-1.61	- .58	.87
47.	.47	.76	- .58	-1.0
48.	- .57	- .19	- .16	.87
49.	- .05	.28	.25	.25
50.	1.00	.76	-1.00	.87
51.	1.52	1.71	1.91	.87
52.	1.52	.76	1.91	.87
53.	1.52	1.23	1.91	.87
54.	- .57	.28	1.5	.87
55.	1.52	1.71	.25	.87
56.	1.52	1.71	1.91	.87
57.	- .05	1.71	.25	.87
58.	1.00	- .19	1.91	.87

TABLE 3.

TABLE SHOWING STANDARD SCORES OBTAINED BY 58 SUBJECTS ON SPACE TESTS.

Subjects	1	2	3	4	5
1.	.93	.47	- .91	1.34	1.41
2.	- .4	.76	- .083	-1.51	1.41
3.	.26	1.05	-1.75	.48	- .25
4.	.26	.76	.75	- .65	-1.08
5.	.26	.47	.75	1.62	-1.91
6.	-1.06	.76	.75	+1.34	.58
7.	- .4	.76	.75	-1.51	-1.08
8.	.26	1.05	.75	.20	-1.08
9.	-1.06	.76	.75	.77	.58
10.	.26	- .12	.75	- .65	1.41
11.	- .4	- .12	- .083	- .65	.58
12.	- .4	1.05	.75	- .37	.58
13.	.26	.17	.75	- .08	.58
14.	-1.73	- .41	- .083	- .94	-1.91
15.	- .4	-2.17	- .083	.48	- .25
16.	- .4	-1.00	- .083	- .94	.58
17.	.26	-1.88	.75	- .37	-1.91
18.	- .4	-1.00	.75	- .48	-1.08
19.	.93	-1.88	.75	- .94	- .25
20.	.93	-1.00	-3.41	-1.22	- .25
21.	1.6	-1.00	.75	-1.22	- .25
22.	1.6	.47	.75	1.62	.58
23.	-1.06	.47	.75	- .65	- .25
24.	1.6	.17	-1.75	1.34	.58
25.	.93	- .41	.75	- .65	-1.91
26.	.93	.17	.75	- .65	- .25
27.	.93	.17	-1.75	- .37	- .25
28.	-2.4	-1.58	.75	- .37	-1.91
29.	.26	-1.58	- .91	.77	-1.08
30.	-1.06	-1.29	- .91	.48	.58
31.	-1.73	- .70	.75	- .65	-1.08

32.	-1.06	-1.00	.75	.77	1.41
33.	-1.06	1.05	-2.58	- .65	-1.08
34.	-3.06	- .12	.75	.77	.58
35.	.93	- .41	- .91	-1.51	- .25
36.	.93	-1.29	- .91	-1.51	-1.08
37.	-1.06	.76	.75	.20	1.41
38.	-1.06	.47	- .083	1.05	1.41
39.	- .4	.76	.75	1.34	.58
40.	- .4	- .12	.75	- .94	1.41
41.	.93	1.64	.75	- .65	.58
42.	-1.06	1.05	- .91	.20	- .25
43.	.93	1.05	.75	- .37	.58
44.	-1.06	-1.58	- .91	-1.8	.58
45.	- .4	.76	.75	- .37	-1.08
46.	.26	-1.58	- .91	.77	- .25
47.	.26	-1.29	- .91	- .65	.58
48.	- .4	-1.00	- .083	-1.51	-1.91
49.	.26	- .12	- .91	.48	- .25
50.	.26	1.05	.75	1.34	.58
51.	1.6	.76	.75	1.62	1.41
52.	1.6	.76	- .083	.77	.58
53.	1.6	1.05	.75	.77	.58
54.	- .4	.76	- .91	- .94	- .25
55.	.26	.76	.75	1.34	- .25
56.	.9	.76	.75	1.62	1.41
57.	- .4	1.35	- .91	1.05	- .25
58.	.26	1.05	- .083	.77	.58

TABLE 4.

TABLE SHOWING STANDARD SCORES OBTAINED BY 58 SUBJECTS ON TIME TESTS

Subjects	1	2	4	5
1.	1.12	1.15	1.37	- .49
2.	.51	1.15	.12	.87
3.	.21	.022	.33	.87
4.	1.12	1.61	.33	.87
5.	.51	.47	1.37	.87
6.	-1.3	- .88	.95	.87
7.	- .09	.022	- .08	.87
8.	- .69	.47	1.37	.87
9.	1.12	.93	1.16	.87
10.	- .09	-1.79	- .50	-1.85
11.	.81	- .65	.75	.87
12.	.81	1.15	-1.33	.87
13.	.51	.25	- .50	.87
14.	- .09	.47	- .29	.87
15.	.21	- .43	- .70	- .49
16.	.51	.022	-1.33	-1.85
17.	-1.9	.022	.75	.87
18.	-1.3	-1.34	- .29	-1.85
19.	.81	.022	-1.12	-1.85
20.	-1.3	.022	-1.12	-1.85
21.	- .39	1.61	- .50	- .49
22.	-1.3	-1.79	.33	- .49
23.	- .39	- .88	.54	- .49
24.	- .69	-1.79	-2.66	- .49
25.	-1.00	.022	- .50	- .49
26.	- .69	.70	- .91	.87
27.	.21	.022	-1.33	- .49
28.	- .39	-1.79	- .70	- .49
29.	-1.3	- .20	-1.33	- .49
30.	-1.9	-1.56	- .91	-1.85
31.	- .09	+ .022	.75	.87
32.	1.12	+1.15	- .08	.87
33.	-1.60	-1.56	- .70	-1.85
34.	- .09	- .43	-1.12	-1.85
35.	-1.60	1.15	- .91	.87
36.	.21	- .43	.75	- .49

37.	- .09	1.38	1.58	.87
38.	1.72	1.61	.12	.87
39.	1.42	.70	1.58	.87
40.	-1.9	.022	-1.12	.87
41.	- .09	- .88	.95	.87
42.	1.12	-1.11	.54	.49
43.	.21	.25	.75	- .49
44.	- .09	.25	- .29	- .49
45.	.51	.93	1.33	-1.85
46.	-1.9	- .20	-2.16	- .49
47.	-1.00	-1.34	.12	- .49
48.	.81	.47	.54	- .49
49.	1.12	- .43	1.37	.87
50.	.81	1.38	.12	- .49
51.	1.12	.47	.95	.87
52.	1.42	.25	-1.12	- .49
53.	1.12	1.61	1.16	.87
54.	1.12	-1.56	- .29	.87
55.	- .69	.47	.12	.87
56.	1.42	- .43	1.79	.87
57.	- .09	-1.56	.75	.87
58.	.81	.47	1.37	.87

TABLE 5.

TABLE SHOWING NUMBER OF CHILDREN IN EACH OF THE SIX A (AGE) GROUPS.

Group	Age Range	Subjects	Total
A_1	6 yrs. - 6.6 mnths.	E.D., H.B., R.M., A.T., A.C., S.B., P.D., C.B., E.F.	9
A_2	6.7 mnths. - 7 yrs.	M.B., S.M., N.A., P.A., J.M., I.F., M.G., H.S., K.S., A.G.	10
B_1	7 yrs. - 7.6 mnths.	C.H., B.J., G.Q., M.W., M.G., R.S., B.G.	7
B_2	7.7 mnths. - 8 yrs.	L.S., A.S., J.S., P.G., K.R., S.G., F.T., W.H., M.T.	9
C_1	8 yrs. - 8.6 mnths.	M.W., S.P., D.A., P.C., D.H., M.L., K.vd.M., G.S., C.D.	9
C_2	8.7 mnths. - 9 yrs.	A.B., G.G., G.Mc.F., J.v.A., E.S., L.M.	6
		* TOTAL	50

* The Eight children (9 to 10 year olds) constitute the fourth S group, hence the total of 50 subjects comprising the A groups, instead of 58.

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TABLE 6.

TABLE SHOWING NUMBER OF CHILDREN IN EACH OF THE FOUR S GROUPS (GROUPS DIVIDED ON BASIS OF SCHOOL STANDARD) AND MEAN AGE OF EACH GROUP.

Group	Age Range	Average Age	Total Number
1.	5 yrs. 11 mnths. - 7 yrs. 4 months.	6 yrs. 6 mnths.	22
2.	7 yrs. 1 mnth. - 7 yrs. 11 months.	7 yrs. 7 mnths.	14
3.	7 yrs. 11 mnths. - 8 yrs. 7 months.	8 yrs. 4 mnths.	14
4.	9 yrs. 2 mnths. - 9 yrs. 11 months.	9 yrs. 7 mnths.	8

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TABLE 7.

TABLE SHOWING VALUES OF "W" (COEFFICIENT OF CONCORDANCE), OBTAINED BY A (AGE) GROUPS (A_1 - C_2) ON NUMBER, SPACE AND TIME TESTS.

Group	Age Range	Number	Space	Time
A_1	6 yrs. - 6 yrs. 6 mnths.	.34	.13	.601
A_2	6 yrs. 7 mnths. - 7 yrs.	.18	.22	.18
B_1	7 yrs. - 7 yrs. 6 mnths.	.093	.42	.42
B_2	7 yrs. 7 mnths. - 8 yrs.	.27	.305	.38
C_1	8 yrs. - 8 yrs. 6 mnths.	.32	.33	.400
C_2	8 yrs. 7 mnths. - 9 yrs.	.43	.25	.33

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TABLE 8.

TABLE SHOWING VALUES OF "W" (COEFFICIENT OF CONCORDANCE) OBTAINED BY S GROUPS 1 - 4 (GROUPS DIVIDED ON BASIS OF SCHOOL STANDARD) ON NUMBER, SPACE AND TIME TESTS.

Group	School Standard	No.	Space	Time
1.	Sub. A.	.26	.22	.38
2.	Sub. B.	.29	.35	.44
3.	Std. I.	.37	.30	.39
4.	Std. II.	.35	.46	.303

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TABLE 9.

TABLE SHOWING VALUES OF CHI SQUARE (x^2) AND CRITICAL VALUES (Ho) ASSOCIATED WITH CHI SQUARE FOR S GROUPS 1 - 4 (GROUPS DIVIDED ON BASIS OF SCHOOL STANDARD) ON NUMBER, SPACE AND TIME TESTS.

	Number	Space	Time
GROUP I.			
x^2	21.84	23.1	31.92
Ho.	.50	.50	.10 *
GROUP 2.			
	Number	Space	Time
x^2	15.08	22.75	22.88
Ho.	.30	.05 **	.05 **
GROUP 3.			
	Number	Space	Time
x^2	19.24	19.5	20.28
Ho.	.10 *	.10 *	.10 *
GROUP 4.			
	Number	Space	Time
x^2	9.80	16.1	8.48
Ho.	.20	.02 **	.30

** Indicates a highly significant Ho. value.

* Indicates a slightly significant Ho. value.

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TABLE 10.

TABLE SHOWING VALUES OF CHI SQUARE (x^2) AND CRITICAL VALUES (Ho) ASSOCIATED WITH CHI SQUARE FOR GROUPS A_1 - C_2 (AGE GROUPS) ON NUMBER SPACE AND TIME TESTS.

	GROUP A_1		
	Number	Space	Time
x^2	10.88	5.2	19.2
Ho	.30	.30	.02 **
	GROUP A_2		
	Number	Space	Time
x^2	6.48	9.90	6.48
Ho	.70	.50	.70
	GROUP B_1		
	Number	Space	Time
x^2	-	8.64	-
Ho	Not significant (Table R)	.05 **	Not significant (Table R)
	GROUP B_2		
	Number	Space	Time
x^2	8.64	12.2	12.16
Ho	.50	.20	.20
	GROUP C_1		
	Number	Space	Time
x^2	10.24	13.2	12.8
Ho	.30	.10 *	.20
	GROUP C_2		
	Number	Space	Time
x^2	-	-	-
Ho	Not significant (Table R)	Not significant (Table R)	Not significant (Table R)

** Indicates highly significant Ho value.
* Indicates slightly significant Ho value.

TABLE 11.

THE PERCENTAGE OF CHILDREN IN EACH S GROUP (GROUPS DIVIDED ON BASIS OF SCHOOL STANDARD) AT "SUBSTAGE" III, II AND I ON NUMBER TESTS TWO - FIVE.

NUMBER SUBTEST 2.		Substage 3	2	1
Group I	Sub. A	22.7%	31.8%	45.4%
Group 2	Sub. B	42.8%	50.0%	7.1%
Group 3	Std. I	57.1%	35.7%	7.1%
Group 4	Std. II	75.0%	25.0%	-
NUMBER SUBTEST 3.		Substage 3	2	1
Group I	Sub. A	9.1%	50%	40.8%
Group 2	Sub. B	35.7%	50%	14.3%
Group 3	Std. I	35.7%	50%	14.3%
Group 4	Std. II	75.0%	25%	-
NUMBER SUBTEST 4.		Substage 3	2	1
Group I	Sub. A	13.6%	18.1%	68.3%
Group 2	Sub. B	14.3%	42.9%	42.9%
Group 3	Std. I	7.0%	43.0%	50.0%
Group 4	Std. II	75.0%	25.0%	-
NUMBER SUBTEST 5.		Substage 3	2	1
Group I	Sub. A	18.1%	59.1%	22.7%
Group 2	Sub. B	78.5%	21.4%	-
Group 3	Std. I	78.5%	21.4%	-
Group 4	Std. II	100%	-	-

TABLE 12.

THE PERCENTAGE OF CHILDREN IN EACH OF THE S GROUPS (GROUPS DIVIDED ON BASIS OF SCHOOL STANDARD) AT "SUBSTAGE" III, II AND I ON SPACE TESTS 1-5.

SUBTEST 1.		"Substage" 3	"Substage" 2	"Substage" 1
Group 1	Sub. A	54.5%	31.8%	13.6%
Group 2	Sub. B	42.8%	57.2%	-
Group 3	Std. I	50.0%	42.8%	7.1%
Group 4	Std. II	75.0%	25.0%	-
SUBTEST 2.		"Substage" 3	"Substage" 2	"Substage" 1
Group 1	Sub. A	13.6%	63.6%	22.7%
Group 2	Sub. B	57.1%	28.5%	14.3%
Group 3	Std. I	71.4%	28.5%	-
Group 4	Std. II	100%	-	-
SUBTEST 3.		"Substage" 3	"Substage" 2	"Substage" 1
Group 1	Sub. A	63.6%	31.8%	4.5%
Group 2	Sub. B	64.3%	35.7%	-
Group 3	Std. I	85.7%	14.3%	-
Group 4	Std. II	75.0%	25.0%	-
SUBTEST 4.		"Substage" 3	"Substage" 2	"Substage" 1
Group 1	Sub. A	9.1%	27.2%	63.6%
Group 2	Sub. B	21.4%	28.5%	50.0%
Group 3	Std. I	21.4%	28.5%	50.0%
Group 4	Std. II	50.0%	37.5%	12.5%
SUBTEST 5.		"Substage" 3	"Substage" 2	"Substage" 1
Group 1	Sub. A	27.2%	36.4%	36.4%
Group 2	Sub. B	64.3%	21.4%	14.3%
Group 3	Std. I	57.1%	7.1%	35.7%
Group 4	Std. II	62.5%	37.5%	-

TABLE 13.

THE PERCENTAGE OF CHILDREN IN EACH OF THE S GROUPS (GROUPS DIVIDED ON BASIS OF SCHOOL STANDARD) AT "SUBSTAGE" III, II AND I ON TIME TESTS, 1, 2, 4, 5.

SUBTEST 1.		"Substage" 3	"Substage" 2	"Substage" 1
Group I	Sub. A	9.1%	40.9%	50.0%
Group 2	Sub. B	42.8%	35.7%	21.4%
Group 3	Std. I	35.7%	50.0%	14.3%
Group 4	Std. II	75%	12.5%	12.5%

SUBTEST 2.		"Substage" 3	"Substage" 2	"Substage" 1
Group I	Sub. A	13.6%	36.3%	50%
Group 2	Sub. B	28.5%	35.7%	35.7%
Group 3	Std. I	35.7%	42.8%	21.4%
Group 4	Std. II	12.5%	50.0%	37.5%

SUBTEST 4.		"Substage" 3	"Substage" 2	"Substage" 1
Group I	Sub. A	-	31.8%	68.1%
Group 2	Sub. B	28.5%	57.1%	14.3%
Group 3	Std. I	35.7%	42.8%	21.4%
Group 4	Std. II	50.0%	37.5%	12.5%

SUBTEST 5.		"Substage" 3	"Substage" 2	"Substage" 1
Group I	Sub. A	22.7%	45.4%	31.8%
Group 2	Sub. B	42.8%	50.0%	7.4%
Group 3	Std. I	85.1%	7.4%	7.4%
Group 4	Std. II	87.5%	12.5%	- %

VIIa. DISCUSSION OF RESULTS.

In terms of the statistical method we have used, Piaget's theory would predict that a high level of concordance should be found between tests constituting any one battery, when administered to a group of children. This would allow one to predict that each child in that group responds fairly consistently on these tests. While Child A might perform at a different level from child B in the same group, the level at which each child functions, should be significantly consistent to assume that the tests administered are, in fact, test parallels. One expects, then, that the W values obtained by each group (standard and age groups) are associated with probability values which enable one to reject the null hypothesis at a high level of confidence. The null hypothesis states that there is no significant agreement between rankings obtained by the same child on a number of different subtests constituting a battery. If lack of agreement between test scores is consistently found among children constituting any one group, then the null hypothesis is accepted for that group, and one may assume that the tests in question, all tap different levels of cognitive functioning. If however the null hypothesis is rejected, the alternative hypothesis must be accepted which states that the agreement between N sets of rankings for each child in the group is consistently higher than it would be by chance, and that the concordance must be attributable to a factor common to all scores which these rankings represent. Piaget's hypothesis would relate this agreement between subtests comprising any one battery to the fact that they all tap facets of a homogeneous intellect which determines, within limits, a stable level of cognitive functioning.

Thirty W values have been computed, eighteen for the six A groups and twelve for the four S groups. For purposes of the present analysis of results we propose

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to reject the null hypothesis when the probability associated with a particular value of W reaches the .01, .05, and .1 levels of confidence. The latter value will be considered as only slightly, but nevertheless, still significant.

Referring to Tables 10 and 9, it can be noted, that out of a possible 30 significant chi square values associated with W, only five are significant and five, slightly significant. This means that only $33\frac{1}{3}\%$ of the W values correspond to a significant chi square value. At this point, then, it seems that lack of agreement between scores on five subtests comprising a number, space, or time battery, seems clearly to be a feature of results recorded for the differently constituted groups in this study.

Owing to the very large discrepancy in W values computed for the S (standard) groups on the one hand, and the A (age) groups on the other, and the implications which may follow from this, it is necessary that the results of each group be considered individually and in detail.

The S groups will first be considered. Outlining roughly their results, one notes from Tables 8 and 9, that seven of the twelve W values computed for the four S groups are significant. Furthermore it is found that at least one of the three W values computed for each group is significant and in addition that Group III (standard one group) obtained slightly significant values of W on all three tests, number, space and time, and group II (Sub B group) highly significant values of W, on space and time tests.

Such a general survey does suggest that when the Piagetean tests, particularly those of time and space, are administered to children in the sample, divided into respective groups on the basis of school standards, there is a tendency for the children comprising these groups to respond with a considerable degree of consistency on the five subtests constituting a particular battery.

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While this statistical procedure naturally limits us in talking in terms of individual children, it appears to be the most adequate tool for our present purpose. Since this method enables one to determine interreliability between tests comprising a single battery when administered to a group, and since these tests are tests of concrete operational intelligence, a significant concordance or lack of concordance between these tests when administered to a small and homogeneous group, can shed important light on the present hypothesis.

From the W values calculated for the S groups, a number of important implications follow. In the first place, it can be noted that only one S group obtained a significant value on the number tests, and even this value falls within the lower significance range. This suggests that the children comprising the independent S groups do not appear to function consistently or uniformly on the five tests comprising the number battery. The fact that significant W values were obtained by each of the four S groups on either space or time tests, and in addition that groups two and three obtained significant coefficients of concordance on both space and time tests, suggests that these batteries more readily tap a homogeneous or stable cognition in their independent areas than the number tests. Since Piaget's theory of critical stages states that adequate maturation and environmental matching provide for a homogeneous functioning in all areas of cognition, it is difficult to conciliate these findings with Piaget's contentions that these tests are measures of a constant level of maturation which cuts across all areas of cognitive functioning uniformly.

On the other hand, there is some interesting support for Piaget's theory in the fact that Groups 2, 3 and 4 obtained significant W values on the space tests and that similarly significant results were computed for Groups 1, 2 and 3 on time tests. The interreliability between the subtests comprising the space battery for the

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aforementioned groups, and a similar consistency between the time tests, suggests that they are significantly homogeneous measures of the cognitive functioning which they have been devised to tap. This naturally applies only within the framework of the groups we are testing.

The latter results have important implications for the first hypothesis. It appears that when the sample is divided into groups on the basis of school standard, a selection of Piagetean time and space tests are in fact measuring a significantly homogeneous level of functioning in most of the groups. However, since Piaget stresses the emergence of the concrete operational stage at about the same time in all content areas, it is incongruous with his theory of homogeneous intelligence that such discrepancy should be found between the number tests on the one hand, and the space and time tests on the other, when administered to one and the same group.

It is interesting to note that Group 3 (Standard I children) obtained three significant W values, one on each of the three content areas, number, space and time. Similarly Group 2 (Sub B children) obtained highly significant W values on both the space and time batteries. Both these groups seem to deviate, then, from Group I (Sub A group), for which only one significant W value was computed, and this falling within the lower significance range. This corresponds well with Piaget's findings, that stable cognitive functioning which characterizes the concrete operational stage emerges generally between the ages of seven and eight. While these results lend encouraging support to Piaget's hypothesis, there are several important points of deviation which relate particularly to our second hypothesis.

It follows that if maturation takes place in clearly defined stages, and this development portends progress in all areas of cognitive functioning, one and the same group should function consistently in all areas. Tables 8 and 9, however, show that, with the exception of the third S group

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at least one of the three W values computed for each of the remaining groups is highly inconsistent with the other. Thus in group one it is noted that the coefficient of concordance (W) computed on the time tests, is associated with a significant probability value which allows one to reject the null hypothesis, whereas the probability values associated with the coefficients of concordance on the number and space tests for the same group enable us to accept the null hypothesis at a high level of confidence. This implies that there is very little interreliability between the battery of space tests when administered to the group, and this applies equally to the number tests. Yet there is a marked agreement between tests constituting the time battery for the group in question. Similarly in Group 2, where highly significant values of W were computed for the space and time tests, a correspondingly low W was obtained on the number tests. Comparable results are recorded for Group 4. While W is highly significant for the space tests, the coefficients of concordance on both the number and time tests correspond to probability values that fall well below the significance levels.

It is difficult to reconcile these findings with the Piagetean theory. Since there is a very marked difference between the concordance values computed for the number, space, and time tests in the case of one and the same group, it is clear that there is a significant lack of agreement between the level of cognitive functioning of this group in the three different areas of cognition. A significant W value as computed for any specific battery of tests, implies that high intra-test reliability exists between subtests comprising this battery when administered to a particular group. It follows, then, that the level of cognitive functioning of each child in that group is significantly stable and constant on each of the independent subtests. On the other hand, if a highly insignificant value of W is obtained by a specific group in one content area, this

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shows that the rankings of the individual children on the subtests comprising the battery is more or less random. Thus, when a highly significant value of W is found on one battery of tests for a particular group and an insignificant coefficient of concordance is obtained on another battery by the same group, one may deduce with some certainty that the two independent batteries are tapping discrete levels of cognitive functioning. It follows, then, that for all S groups, with the exception of Group 3, a significant degree of inter-test variability exists between the three content batteries and hence there is some inconsistency of functioning in the areas of number, space, and time conception.

On the other hand, although the probability values associated with the coefficients of concordance are identical on the number, space, and time tests respectively in the case of S group three, and although significant probability values are associated with W's recorded for S group two on both space and time tests, one must recognize certain limitations in making immediate deductions about the relationship between number, space and time cognition for these groups, using Kendall's method. Whereas marked discrepancy between three W values, computed for any one group, indicates discrepant functioning on the number, space, and time tests, the reverse deduction cannot be made even if significant concordance values are obtained on two or three of the test batteries, or even when this value is identical for each content area (Group 3). While this statistical method serves to verify intra-test reliability between a number of tests constituting a battery, an identical concordance value on number, space, and time tests, as computed for the same group of children, does not necessarily indicate inter-test realiability between these batteries. It may well be that the rankings of a subject which contribute to the computation of a significant W value on the number tests in Group 3,

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are differently constituted from those underlying a significant W value on the space and time tests. Thus on the number tests, subject A may rank fifth on all the subtests, whereas on the time tests, he ranks consistently second on all subtests. Both these results would contribute to a high value of W, and yet there is a marked discrepancy between the child's space and time results. He is, in fact, functioning at a very much higher level in the one content area than in the other. This is an important limitation of the statistical tool we have used, and one that must be recognized before making hasty deductions.

In concluding this discussion of the S groups, it can be said that the W values indicate a certain degree of internal consistency between subtests constituting the space and time tests for most groups. However, this stability seems to be markedly lacking in the number tests for the majority of the S groups. In considering the relationship between the three content areas of number, time and space, for these groups, there are strong indications of inter-test variability among the three content batteries selected. Since this inconsistency of functioning cannot be accommodated by Piaget's theory, one can tentatively say that we have in these results some discredit for our second major hypothesis.

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We turn now to a survey of the W values obtained by the 6 age groups. Eighteen W values were computed for the A groups, three coefficient values for each specific subgroup. Perusal of Table 10 shows that of the 18 W values computed, only three (16%) correspond to significant chi square values. This implies that when the space, number and time tests are administered to the independent subgroups there seems, in general, to be little internal consistency or interreliability between the subtests constituting any one battery for the groups

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Considering the results in greater detail, several interesting points emerge. In the first instance, there is little doubt that even a brief consideration of Tables 10 and 9 indicates that there is a significant difference between the groups constituted according to age on the one hand, and school standard on the other. The comparison of the W values obtained by groups A and S provides perhaps the most interesting finding which has emerged from this project. From the results obtained, it seems clear that when the Piagetean tests were administered to the sample groups delineated purely on the basis of school standard, the likelihood of a significant coefficient of concordance between these tests was greater than in the case of the same children grouped according to age. There are several explanations which may account for the present finding. Since it is possible to deduce from the results that the S groups are more homogeneous than the A groups with regards to cognitive development, as measured by the Piagetean tests selected, one can perhaps attribute these findings to certain experiential factors common to the independent S groups. Thus, for example, the third S group may be particularly homogeneous, not only as a result of a fairly comparable home environment and level of mental maturity, but also as a consequence of the years of schooling, the degree of interpersonal relationship, and the added cognitive stimulation which accompanies the school programme. It is this latter factor which is not necessarily constant in the A groups for as was pointed out earlier, it is possible that one and the same A group may be constituted of children who are not necessarily in the same school standard. While the majority in each group naturally are, the lack of homogeneity which has been noted may be introduced by the two or three children in each A group, not belonging to the same school standard as the others. While these results do not infirm Piaget's contentions, they suggest

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that Piaget's cognitive theory has perhaps not given as much emphasis to the effects of experiential determinants as is necessary for an adequate survey of cognitive development.

If one considers in more detail the individual W values obtained by the 6 A groups and the chi square values associated with them (Table 10), one notes that only Group A_1 (6 yrs. - 6 yrs. 6 months) received significant Coefficients of Concordance on the time battery and Group B_1 (7 yrs. - 7 yrs. 6 months) and C_1 (8 yrs. 7 months - 9 yrs.) obtained significant W values on the space tests. No significant W values were obtained on the number tests for any of the subgroups. This finding agrees strongly with what was found in the case of the four S groups. The fact that no significant W values were obtained by the 6 A groups on the number tests, confirms an earlier finding on the S groups that these tests, in particular, appear to be characterized by a significant lack of interreliability and inconsistency. They appear to tap different levels of cognitive functioning, a tendency which is marked far more in the case of the number tests than in the time and space tests for the group in general. However, the fact that only two of the S groups obtained significant W values on the space battery, and only one group received a significant coefficient of concordance on the time battery, suggests that even on these tests there was little consistency in the cognitive functioning of the S groups considered in toto.

The results obtained by the 6 A groups also present a serious objection to our second hypothesis which states that the child's cognitive development is parallel within the three content areas of number space and time. Referring to Table 10, we note that although three subgroups received significant W values in at least one content area, grossly insignificant coefficients of concordance are recorded in the remaining two areas for the same groups, suggesting clearly an

inconsistency/...

inconsistency of functioning in the three content areas by the groups in question.

While we have discussed differences which have emerged in protocols of children in the various age and class groups, the perusal of the raw scores presented in Table I a, b, c brings to light a point which the computation of Kendall's Coefficient of Concordance alone does not make clear. This relates to the fact that the S group four, (9 year olds) are in general superior to the preceding groups on the number tests. Five children in the group are clearly functioning at the third stage level, while the remaining three children show deviations from this level on only one or two of the number tests. This marked trend of improvement found in this group over the younger children in this study is not as clearly discerned in the tests of spatial conceptualization, although it might be noted that this group shows clearly an advancement over the others on the perspective's test. In the case of the time tests, however, there seems to be no marked superiority in this group over the younger groups. The lack of consistency between the various content areas for S group four (standard two children) and their superior performance on the number subtests allows for a number of interesting deductions. The apparent consistency in the number test scores of the subjects in this group, and the fact that the majority are able to solve all tasks with efficiency, might well lead one to conclude that in this group concrete operational reasoning has been attained. There are, however, several reservations which must be made. In the first instance, it is clear that if we administer the Piagetean tests to progressive age groups, we will eventually find a group in which every child has the capacity to solve all tests adequately. It is obvious that the children in this group would be capable of operational reasoning and true conceptual thought. But such a finding would provide no adequate support for Piaget's contentions. In the first place,

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there is no substantial proof that in this specific group conceptual development had followed precisely the course which Piaget predicted. This is our first consideration, but there is another which emerges from the pattern of results obtained by S group four. Can one, in fact, talk in terms of a new "stage" of development in these children? There is certainly evidence of concrete operational development in the case of their number scores, but since there is still gross intra-test variability between the time tests for this group, can they be readily assigned to the concrete operational stage? This finding is considered as one of the most serious pointers against accepting Piaget's theory without amendment. If at the nine year level, children in this study are at the concrete operational stage in number conceptualization but generally show a motley pattern of operational and pre-operational reasoning in their time protocols, there is some evidence against Piaget's idea that broad bands of cognitive development cut across different content areas at about the same time in the life of every child. The fact that operational reasoning in the present group emerges sooner in one area than in another is particularly difficult to explain in terms of Piaget's theory of cognitive stages and a homogeneous intelligence.

The final implications which follow from the computation of W scores must now be considered. From Tables 10 and 9 it is found that the five Piagetean space tests selected for this study have greater intra-test reliability than either number or time tests, as computed by Kendall's Coefficient of Concordance. Referring to Table 10, we note that two of the three significant W's computed for the A groups were those on space tests, and complementary to this, it was found that three of the four S groups also obtained significant W's on the space tests. In the graphs of the individual test protocols which will be discussed later, this tendency is particularly marked. The graphs representing scores on the five spatial

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tests for individual children are predominantly flatter than those for time or number, suggesting that the spatial tests may be considered as test parallels.

This tendency towards concordance between the five spatial tests selected suggests interesting possibilities. In the first place it is axiomatic that if there is high internal consistency between the space subtests, one can say with some certainty that these tests are fairly consistent measures of the same level of functioning. It is interesting particularly, that this should be found within the sphere of spatial cognition. This is a point which may well be linked to a suggestion made in an earlier section, that Piaget stresses the importance of sensory-motor activity far more in the case of spatial cognition than either in the case of number or time. The tests which he has devised support particularly his contention that adequate spatial conceptualization can only emerge when actions are internalized and these are co-ordinated to form operations. In the case of number and time tests, this immediate dependence on sensory-motor activity for adequate conceptualization is far less easily detected. It follows that if spatial conceptualization is so predominantly dependent on adequate sensory-motor activity and co-ordination of internalized actions, it is likely that conceptualization in this area will readily take place <u>if the objective or physical environment is sufficiently enriched</u>, and the child is given the opportunity to explore and test out the situation. In other words, spatial conceptualization is predominantly dependent on the external or objective environment, and adequate development in this area can perhaps be <u>more readily divorced from affective determinants</u> than can cognitive development in other areas. Piaget's theory stipulates that adequate maturation of brain structures must take place before the child can adaptively employ the objective environment, but provided these two conditions are present conceptualization occurs. Since the present group is a

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particularly homogeneous sample coming from stimulating and rich environments, it may well follow that the requirements of an adequate objective or physical environment have been provided for each child. Furthermore, since the age range of the sample covers broadly what Piaget has defined as the concrete operational stage, one expects that a significant number of subjects will show more or less consistent functioning on the spatial subtests devised to tap operational reasoning. Our results then confirm the deductions which can be made from Piaget's theory.

There is one significant question which follows however. What accounts for the significant difference which has been noted between the space tests on the one hand and the number tests on the other? How can one explain the finding that space tests appear to tap a significantly consistent capacity in 50% of the subgroups, whereas the number tests are apparently measuring a heterogeneous functioning in the great majority of groups. There are two explanations for this finding. Either the Piagetean number tests are not adequate to tap a homogeneous capacity, or such a homogeneous capacity does not exist and we cannot talk of "stages" of intellectual development as Piaget does. Since as we have shown, Piaget stipulates that the former condition is provided by his tests, the latter possibility seems particularly likely. The consequence is that one talks of a homogeneous development in spatial conceptualization which supports the contention of fixed stages, and uneven development in number conceptualization, which goes counter to the idea of clear-cut sequential stages. This inconsistency might be explained by a point mentioned earlier. It is difficult to see how number conceptualization is as predominantly linked to sensory-motor activity as is spatial conceptualization, and the link seems even more remote in the case of time concepts. This might account for some of the discrepancy we have noted. It is perhaps the case that extraneous variables enter

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into time and number conceptualization with greater propensity than they affect spatial conceptualization. Whereas the latter seems very much to be determined by sensory-motor activity, time cognition, in particular, may be less closely affiliated to this activity and it is possible that personality variables in addition to purely cognitive factors determine the inconsistent performance that has frequently been noted in the protocols of one and the same child.

Why there is such gross inconsistency for the individual child on number tests it is difficult to determine following purely the theoretical contentions of Piaget, but it seems to us that the operations underlying number conceptualization as outlined by Piaget, are less immediately determined by actual physical actions fundamental to space conceptualization. It is possible that spatial conceptualization as related directly to sensory-motor activity (physical actions), and the internalization and co-ordination of these, is more closely determined by maturation of underlying brain structures in the child than are operations underlying number and time conceptualization. In the case of number and time conception the immediate link between biological organization on the one hand (determined by maturation and the organizational concomitants of assimilation and accommodation), and behaviour on the other, may be camouflaged by the effects of chance experiences (training) or certain personality determinants, so that a coherent pattern of behavioural development is not found to correspond with the concise and clear-cut pattern characteristic of the biological organization which Piaget has traced.

In concluding a discussion based on the statistical analysis that has been conducted, it is necessary to consider in some detail the general trend which emerges from a series of graphs that have been presented (see appendices).

Seventeen graphs have been drawn, each representing

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the scores on number, space, and time tests of randomly selected children in the sample. Four children were drawn for this purpose from each age group and five were selected from the six to seven year group.

The main purpose of these graphs is to reveal any striking or gross discrepancies in the protocol of one and the same child. The graphs are drawn on the basis of raw score data (Tables 1a, b and c), and for this reason an identical percentage on different subtests does not necessarily have an identical connotation. On the other hand, as we pointed out earlier in discussing the methodology, it is impossible to define precisely the stage corresponding to any qualitative score on the criteria which Piaget gives, for even on subsections of the same subtest, discrepancies in the level of cognitive functioning were noted in the case of some subjects. However, a point which emerges from these graphs and which for the present purpose is adequate, is the presence of any striking or predominant discrepancies in one and the same content area for any particular subject. It is obvious that the child is functioning at different levels on two tests if she obtains a quantitative score close to the 100% mark on the one test and a score which approaches the 0% level on the other. Furthermore these graphs serve to show the rough relationship between the subject's functioning in one content area and another, and in particular also help to determine whether the children generally tend to function more consistently in one content area than in others. This method is in our opinion the closest one can come to representing and discussing scores of the individual child in the sample.

A very general survey of the graphs presented leads to the conclusion that there is frequently a gross inconsistency in the test scores obtained by the individual subject in one and the same content area. This is represented by sudden severe dips in the graphs, or sporadic rises, a characteristic which can be noted in a

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number of the graphs presented (eg. J.v.A., P.A., T.J.) Turning to the more specific aspects of these graphs, a number of interesting findings can be deduced. It appears from a brief survey that graphs representative of the child's cognitive functioning on the five space tests selected are significantly flatter than those depicting number and time scores. In approximately ten of the seventeen graphs this can be clearly noted. The lines representing the five scores do not fall into the same plane, but the variation is slight enough to deduce a fair degree of consistency in cognitive functioning on the tests in question. It is interesting that this finding is in close agreement with what we were able to deduce from a computation of "W Scores" on the space tests for the differently constituted subgroups, and with the conclusions which were drawn at that point. It still has to be conceded from the remaining graphs that consistent performance on the spatial tests is by no means a generalized occurrence (eg. H.B., D.H.) One can only deduce that there is a stronger tendency in this direction on the space tests than on the number and time tests, in the case of the present sample. Furthermore, the graphs representing the number and time scores of the seventeen subjects selected, reveal a marked degree of inconsistency in the cognitive functioning which they represent and this seems to be particularly applicable to the number protocols. This latter tendency would again follow on relevantly from what we could conclude from the W scores computed for the different groups on the number tests. It might be recalled at this point that only one of the ten W values computed for the number tests was significant, and even this value fell within the lower significance range.

Turning now to the question of whether there are any clearly definable age trends to be noted from the graphs drawn, it appears only from the number protocols that any marked improvement is noted, and that

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in the nine year old group. (L.L. and E.B.) However, the remaining two graphs representative of children in this group still show a fair degree of inconsistency in functioning in this area. On the time tests also, gross inconsistency in performance can be noted from graphs presented for this group suggesting no very marked improvement over the prior age groups. It appears, then, that even in this advanced age group intra-test agreement between number, space and time, is still not a feature of the results recorded.

A further aim that was considered in presenting the graphs is to show roughtly the nature of the relationship between the individual subject's functioning in one content area and another. In considering this question it can initially be said that there appear to be large variations in the type of graph pattern which we get. In the case of some subjects consistency of functioning in all content areas seems more pronounced than in the case of others. For example, we note a fair degree of consistency in the number, space and time tests from the graphs of E.B., K.R., and M.W., but even these graphs reveal inconsistent dips at one or two points. In the case of other subjects eg. E.F. consistency of functioning seems to be predominant in one content area, but markedly absent in the others. In these children the consistent functioning seems inevitably to be within the sphere of spatial conception. In the case of still other subjects (eg. H.B. J.v.A.) inconsistencies are found in all three content areas. These results, then, point to the fact that consistent functioning in all three content areas does not seem to be the trend in the present sample. This finding further invalidates Piaget's contentions that at the concrete operational stage the child should function consistently in all three content areas, and within one and the same sphere of cognition.

In concluding this discussion on the graphs presented, we may consider a subtle point which Piaget's

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experimental design may not have brought to light, and which certainly cannot be deduced from the pattern of examples which are quoted in the Piagetean content books.

Piaget has implicitly stated that at the concrete operational stage certain logical operations evolve simultaneously. This we have already shown by quoting Piaget in our discussion of the concrete operational stage. The tests he has devised are said to tap the child's ability to employ these specific operations adaptively, and for this reason the tests in question can be considered as test parallels. It follows that the child who has reached the concrete operational stage should respond consistently on all these tests, if as Piaget claims, each taps different facets of the operational reasoning which emerges at this level of development. Nevertheless from the graphs selected and from the raw score tables (Tables 1 a, b, c), it appears that some tests are found more difficult than others by the groups in general. This applies particularly to number test four and the second time test, and to a lesser extent to space test four. This is certainly not applicable to the protocols of every child and it is frequently the case that a child employs conceptual reasoning precisely on these tests and fails on tests which are commonly found easy by the group. Thus, for instance, in the time protocol of H.B. a Sub A child, we note a 100% on the second time test but prelogical functioning on three of the remaining time tests. It is of course possible that this child has reached the concrete operational stage in time conception but that owing to affective variables she shows regression on certain tests. Similarly subject P.G. functions at a level well over 90% on the second time test, but comes down noticeably on the remaining four time tests. Still other subjects, for example K.v.M., perform at a consistent level on all time tests showing no specific drop at points of apparent difficulty. Similarly on number test

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four some subjects, notably C.H., a Sub A child, present a complete operational solution on this task, but function at a lower level on the remaining tests in the battery. However, the fact that these tests appear to present more difficulty than others requires some consideration. It may well be that the operations underlying these tests are more complex than others, and that they are dependent on more complex structural organization and additional maturation. It is of course also possible that some tests are basically more appealing than others owing to the nature of the test material or the task itself. These situational variables in particular may have enormous influence on the quality of the child's cognition and are factors which Piaget has never considered. That some tests are fundamentally easier than others may, however, not have been elucidated by Piaget's experimental procedure in which the different subtests constituting a battery were apparently administered to different children, and only on this basis, deductions made. In the present study where the five subtests constituting any one battery were administered to <u>each child</u>, it follows that the tendency for one test to be consistently more difficult than others will more readily emerge from the test findings. It is only on the basis of this test procedure that such a tendency can possibly come to light, and this finding points to still further dangers inherent in the experimental procedure which Piaget has adopted. However it was not the purpose of this study to discredit this aspect of Piaget's work, and on the basis of the exceptions, some of which have already been noted, we have no grounds for doing so at this point. That operations evolve simultaneously is one of Piaget's basic contentions that has been accepted and on the basis of which this project was conducted. The fact, however, that certain tests appear to be basically more difficult than others, points to the necessity for adequate <u>standardization</u> of the

Piagetean tests before we can prove or disprove Piaget's major hypotheses with any accuracy.

In concluding this discussion, it may be said that inconsistency in functioning within one content area and between one major content area and another, appears to be the most marked feature in the majority of graphs presented. A notable consistency of functioning appears to be characteristic only of those graphs representing spatial conception in ten of the seventeen subjects, suggesting that in this field of cognition the child's cognitive functioning is significantly more consistent than in others. Furthermore, no marked age trends were noted, although the nine year olds appear to function more consistently on number and space tests than was found in the graphs of the immediately preceding age groups.

At this point we conclude the statistical analysis and turn our attention to a purely qualitative assessment of the results obtained.

b. Qualitative Analysis of Results.

The decision to conduct a purely qualitative analysis has been taken for a number of specific reasons. The statistical analysis that has been undertaken, while revealing in many respects, tends to obscure the extent of the individual differences which a study of the independent protocols leads one to assume. Then too, a number of unusual protocols were obtained for which we find no provision in Piaget's theory, and these should be considered.

A qualitative analysis of the results can be broached from many points of view. This discussion will be purposely limited as only those aspects will be considered that are of immediate relevance to our hypothesis.

The Piagetean hypothesis, if correct, makes this provision, that the results obtained by the individual subject on tests in any one content area will be closely

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analogous to one another, and in addition, that the results in one content area will simulate results in others. A brief study of the graphs that have been presented shows that even in a minority of subjects this trend is scarcely found. The variety of forms which the individual test patterns take are too numerous to mention. Rather, we shall consider at random the protocols of several subjects at different age levels, and note the extent to which they diverge from the patterns which Piaget would predict.

It might be said in defence of Piaget that the subjects in this study are at an intermediary level, and that this accounts for the motley patterns which were recorded. But there are several reasons for discounting this view. In the first instance, the children in this group constitute those who are considered by teachers and on the basis of school work, to be the most intellectually advanced in each class. Although their I.Q.'s were not available, it must be assumed that these fall into the high average or superior level. On this account, we may well expect that most of the seven year olds, and certainly the eight and nine year olds, have reached the concrete operational stage of development. In the second instance, even if the children are at an intermediary stage of development, Piaget's theory would hardly make provision in one and the same child for operational solutions on two or three of his tasks and failure on the remainder. Since Piaget's theory predicts that a homogeneous intelligence underlies all areas of cognitive functioning, we expect the pre-operational child to respond <u>uniformly</u> at the intuitive or intermediary stage. The fact that gross inconsistency of functioning is sometimes noted in the test protocols of many subjects requires explanation. The problem we are faced with is the pin-pointing of those determinants underlying the incongruity which has frequently been recorded.

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There are several alternatives which may be adopted in attempting a solution. It is possible to surmise that Piaget has failed to give sufficient weight to the effects of training, or personality factors of the child contribute more to his cognitive functioning than Piaget has allowed for in his theory. Alternatively it is possible that the very roots of Piaget's theory, his idea of a homogenous intelligence and development in fixed and clear-cut stages, requires some amendment and revision. Although these questions require extensive research programmes before one or other view can be accepted, we propose briefly to note points which emerged in the present study and which, we feel, might throw light on some of these alternatives.

Before this line is taken, it is necessary to give examples from several protocols which illustrate most clearly the inconsistency of scores obtained by an individual child on one and the same battery of tests. These examples will be drawn from each of the age groups studied.

A particularly interesting protocol is that of M.W. an eight year old subject. From the results obtained on the number subtests, four responses are clearly indicative of operational reasoning (Table 1a Subject 1). On the third subtest, however, the child seems clearly to respond at a pre-operational level. While the subject can seriate the sticks constituting the "staircase", she fails completely in inserting the extra sticks. This second set was randomly inserted and while the child perceived that the completed "staircase" was incorrect, attempts at reconstruction by trial and error still failed. At no time did she attempt to measure one stick against others in the series as is characteristic of the operational child. Furthermore the subject was unable to state the correct number of stairs "which the doll has already climbed". In giving an answer she failed to take into account

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the stair on which the doll had come to rest. This response is again clearly pre-operational in nature. If a unitary intelligence underlies number conceptualization, it is difficult to explain in terms of Piaget's theory this inconsistency between the child's cognitive functioning on the third number test and her functioning on the remainder of the number tests.

Test protocols were also obtained which revealed that on one and the same subtest, the child's responses were sometimes characterized by discrepant cognitive functioning. The space protocol of subject A.G. for example (Table 1b, Subject 27), shows that on the fourth subtest (perspectives test) the child could readily construct a straight line between two posts placed midway along adjacent sides of a rectangular table, but implicitly followed the curve when constructing the line on the cardboard round provided. The solution of the former task is clearly indicative of conceptualization and operational thought processes. The fact that the child centrates on the perceptual cues of the stimulus configuration in the solution of the latter task, suggests little more than a first stage response. This incongruous functioning by the child on one and the same subtest is a tendency which has occurred repeatedly in this study, and one that provides a serious objection to the idea of fixed stages of development and a unitary intelligence.

The test protocol of subject M.T. (Table 1c. Sub. 38) also suggests the difficulty of making generalizations over the subtest scores appertaining to any one content area. The time protocol of this subject shows clearly third stage responses on each of the time tests with one exception. It was noted particularly with what fluency and accuracy the child set about each task. However in the case of subtest four (elm and oak tree experiment) there was a marked drop in the score obtained by the child. The subject appears clearly to have resorted to the perceptual cues

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provided by the situation in making her judgement, something which is predominantly found in the reasoning of the pre-operational child. In answer to the question whether the apple or pear tree is older (second subsection of test) she stated the following:- "The pear tree is older because the apple tree has only half the branches." The child in relying on the perceptual cue provided by the stimulus, fails to consider the most important aspect of the situation, the birth order of the trees in question. This overdependence on the perceptual cues of the stimulus configuration is the most salient feature of the pre-operational response. A very similar response was given by this subject on the third subsection of the test. The child was presented with a card on which were depicted an apple and peach tree. Two apples hang on the apple tree and six peaches are shown on the peach tree. In answer to the question "Which tree is older, the apple or the peach" she stated as follows. "The peach tree is older because it has six peaches but the apple tree only has two apples". This response is again a clear indication of the child's overdependence on perceptual cues in reaching her conclusion. The child's reasoning on this test was quite inconsistent with the operational and logical thought processes, which characterized her cognitive functioning on the remainder of the time tests. If, according to Piaget, the maturation of certain brain structures provides a unitary capacity underlying all conceptual thought, what accounts for this apparent regression on one test? The occurrence of such a protocol is not an isolated case, and while it provides perhaps the most lucid and revealing example, there are others very similar in form. Thus, for example, subject A.B., an eight year old (Table 1b. Subject 2), while performing at a high level on four of the space tests, receives approximately 8% on the perspective's test. Again the result is inexplicable in terms of Piaget's theory.

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A further unusual protocol is that of subject H.B. (Table 1c, Subject 21). This child obtained full marks on the second time test, which has generally been found to be one of the more difficult tests in the series. yet her performance on time test four is clearly indicative of pre-operational reasoning, and a strong dependence on the perceptual qualities of the situation. In section one of time test four, for example, the child stated that the elm tree was older "because it is taller". In section two of the test, she failed to establish the correct correspondence between the apple and pear trees at the two and at the three year level respectively. In each case correspondence was determined by the size of the trees in question and not by their birth order. In section three of the test the child also failed to discriminate the ages of the apple and peach trees when the card was placed before her. The following response was recorded. "I can't tell which tree is older or younger. They both look the same size." In this case the subject did not centrate on the perceptual cues provided by the different number of fruit depicted on each tree but relied on an equally unreliable perceptual cue, the size of the two trees. This example shows clearly the extent to which the child's reasoning is distorted if she is over-dependent on the perceptual cues provided by the stimulus configuration. On the other hand, it is clear from the child's reasoning on time test two (dog and rabbit test) that deductions were made only after careful consideration of various aspects of the situation, the basis of true conceptual thought. Thus in considering the duration of the running times of the dog and rabbit, the subject co-ordinated such aspects of the situation as the simultaneity in the starting and stopping times of the two objects, and accounted for the final placement of the dog beyond the rabbit by referring to the greater speed with which it was propelled. The following

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response was recorded. "The dog and rabbit ran for the same time". How do you know? "Because I saw you pushing them at the same time and you made them stop at the same time, so they must have run for the same time". From this example it is clear that there is a marked distinction between the child's reasoning on this test and the pre-operational responses that were recorded on time test four. Again one might inquire into the cause of this discrepancy.

Perhaps the results of subject L.L. a nine year old child (Table 1c. Subj. 56) are most highly incompatible with the Piagetean theory. This subject as rated by the teacher is considered the most intelligent of the standard two pupils, receiving an aggregate each term of approximately 95%. In all three content areas, third stage responses were obtained. The only radical exception was found in the case of the second time test. The subject, scoring only 6 out of a possible 15 points, based her judgements exclusively on the spatial characteristics of the stimulus configuration. In support of her contention that the dog had run for a longer time she stated "Because it has run a longer way and has stopped beyond the place where the rabbit stopped. So when the rabbit stopped, the dog went on running." This response is little more than that characteristic of the first stage child, showing complete dependence on the perceptual characteristics of the situation.

Even in the case of several other nine year old children, enormous discrepancies were found to exist between one or two of the subtests and the remaining tests in the battery. Subject A.G. (Table 1c. Subj. 52) while apparently functioning at the third stage level on most tests, gave exceedingly poor responses on time tests two and four. The protocol of subject S.B. (Table 1c. Subj. 54) also presents an irregular pattern of results. Thus, on time test two this child was found to obtain only one point out of fifteen, and to resort

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completely to the perceptual nature of the stimulus configuration. Owing to the unusual response at this advanced age level, re-questioning was instituted, and again the child was found to state with considerable conviction what had been recorded earlier. A similar deficiency in conceptualization was noted in this child on the perspective test. In constructing a line with matchsticks, she was inclined to rely on the perceptual cues provided by the straight sides of the rectangular table and the curved edge of the cardboard round. This is a characteristic of the pre-operational child. Similar discrepancies in test scores are also noted for nine year old subjects F.mc.D. and T.J., both of whom appear to have resorted to perceptual cues on several tests.

There is little doubt that the concrete operational stage, as defined by Piaget, should be attained by subjects in the nine year group, particularly if we consider that these children were selected by teachers as those who were the most mentally mature and intelligent in the class.

It would be wrong to conclude as one might readily be inclined to do from the above discussion, that inconsistency in test scores is a general rule for every child in the sample. There are children eg. E.F., S.M., and M.B. (Tables 1a, b, c.), who show uniform weakness on all tests, irrespective of the content area. This finding raises an interesting question. What accounts for the congruity between tests scores attained by some subjects, and the marked lack of consistency between test scores obtained by others? In other words, how can we account for the fact that cognitive functioning is significantly homogeneous in some children, and heterogeneous in others? Do we tap here the differential effects of experience, or are differences to be attributed to personality variants? Finally, is it possible that Piaget's theory of stages is perfectly tenable, but that he has set limits which

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are too narrow? Is it the case that maturation of brain structures at any one level of development facilitates a wide scope of cognitive functioning, but that the test pattern noted for any one child is not the immediate consequence of adequate environmental matching alone?

In considering these questions, we propose to discuss in particular the effects of two variables which may influence cognitive development to some extent and perhaps mask the course of cognitive growth in the clear-cut stages which Piaget has outlined. We refer specifically to the effects on cognitive development of personality variables on the one hand, and the effects of training and idiosyncratic experiences of the child on the other.

The effects of chance variables on cognition as elucidated by this study will first be considered. One of the clearest indications of the predominant effects of chance experiences on cognitive development, can be seen from the nature of responses given to time subtest four. In the case of the first subsection of the test, in which the child is required to distinguish the ages of an elm and oak tree, the operational children were frequently found to give the following answer, "I can't tell, because I don't know the number of rings in the stem." When questioned as to the source of this knowledge, the children related their answers to what they had learnt in "Brownies" or had heard from a mother or older sister. From Piaget's theory it is clear that the operational child has the ability to synthesize or co-ordinate simultaneously a number of aspects appertaining to the situation. The relevant application of past knowledge to present circumstances would then be characteristic of operational thought, and readily accommodated by Piaget's theory. However, in the case of children where chance experiences of this nature are absent, and this knowledge cannot be readily assimilated with other apsects of the situation the

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child may more readily turn to the perceptual qualities of the stimulus situation. In this case, the significant difference between the two children under discussion would perhaps be more readily attributable to differences in their experience or training, than to predominantly different levels of maturation in the cognitive structures underlying their intellect.

The effects of training conditions on cognitive functioning was also noted particularly in the second section of time test four. It was found that a large number of children in this sample performed significantly better on the second section of time test four than on the first. On going into this more carefully, it was realized that the child's attention was drawn to the birth order of the trees in introducing the second subsection of the test, a condition which is absent in the case of subsection one. It is interesting to note that when the children's attention was drawn to this aspect of the situation, this criterion was thereafter employed by the majority of subjects in qualifying their responses on this subtest. This is a clear example of the extent to which experiential determinants provided by the test conditions themselves can influence the child's functioning.

One of the most serious omissions in Piaget's work is this failure to take into account the extent to which experiential factors can influence the child's cognitive functioning. It is possible that even small changes in test instruction, the length of these instructions or the nature of the test material itself may influence the child's cognition to a great extent. The inconsistencies noted in the test protocol of one and the same child may readily relate to these factors; yet no provision is made for them in Piaget's theory. Whereas Piaget stresses the necessary interaction between organism and environment for adequate cognitive development, and allows in his theory for the effects of environmental determinants on cognition

by the principles of assimilation and accommodation, the influence of chance situational factors such as we have noted above, does not appear to be sufficiently controlled by his procedure. The fact that the very nature of the test instructions can exert such a strong influence on the cognitive quality of the response, does not seem to have been fully recognized by Piaget. On the basis of these findings we may also suggest tentatively that further research be directed towards better standardization of the Piagetean tests, in order to ensure that they are uniform measures of concept formation per se.

The effects of these chance factors on cognition was not, however, as pronounced in this study as the influence of personality variables on cognitive development. It is interesting to note from the protocols obtained that the effects of affective variables on cognitive growth and developemnt appear to be more potent, or certainly more revealing in the case of <u>time</u> than in either space or number conceptualization. This relates pertinently to a suggestion made earlier, that time concepts, by virtue of their origin, are theoretically more susceptible to the influence of affective variables than are concepts of space or number, and that disturbances in the earliest interpersonal relationship between mother and child may well have a bearing on the child's conceptualization in the area of time. It is necessary that we briefly look into these points, for if affective determinants influence development in one area of cognition to a greater extent than in others, it is reasonable to assume that the broad band of cognitive development which Piaget claims cuts across every area of conceptualization, is to some degree masked or camouflaged by these determinants.

From the protocols obtained, a number of unusual test patterns were recorded which in certain cases we were able to relate directly to obvious personality

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determinants, or to aspects of the child's history which emerged during the testing programme.

From a study of the time protocols, it seems particularly in the case of subtest two that responses given to qualify a particular response are most elucidative of the extent to which subtle personality determinants can have bearing on the child's cognitive functioning. In this test, which determines the child's ability to differentiate spatial from temporal intervals, two objects, a toy dog and rabbit, are made to run for identical durations, but since the one object is propelled at greater speed than the other, it is spatially more distant in its final placement. One of the standard questions put to each child on this test is the following. "If the dog stops at lunch-time, does the rabbit also stop at lunch-time, before lunch, or after lunch?".

The following responses among others were recorded:-

Subject (E.S.):- The bunny also stops at lunch-time, because it wanted to do the same as its friend.

Subject (S.G.):- The rabbit also stops at lunch-time, because everyone must stop at lunch to eat.

Also in questioning the children as to the simultaneity of the starting and stopping times of the two figures, the following response was recorded:-

Subject (P.A.) The dog runs for a longer time, because it must win.

It seems apparent from these replies that cognitive reasoning has to some extent been subordinated to a number of affective determinants. There is surely a significant difference between these children and the child who qualifies her reasoning by reference to spatial or perceptual cues. In the latter case, the

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child might state that the dog came to a halt later than the rabbit, "because it has travelled a longer way" (Subject S.B.) or that "the rabbit stopped, but the dog still had further to run" (Subject C.H.). The pertinent difference lies herein, that these children dissociate themselves from the stimulus situation which is considered objectively, but since their reasoning is still pre-logical in character, the purely perceptual characteristics of the situation are predominant in determining their thought processes. In the case of the former children, however, there is no clear dissociation between the subject and the event. These children integrate themselves with the situation to the extent that it is no longer considered objectively, but as a personally relative event. Furthermore, we are limited in stating with certainly whether, in fact, the reasoning of these children is pre-logical in nature. The emotional qualities exert to some extent a masking effect on the cognitive capacity of the child. The response that the dog and rabbit stop at identical times, "because the dog wanted to do the same as its friend", conceals entirely whether the child is, in fact, also capable of co-ordinating various cognitive aspects of the situation, and so making the adequate deduction, or whether this capacity has as yet not developed.

An interesting point, which also relates to the effects of affective influences on cognition, was noted in the time protocol of Subject G.Q. (Table 1c, Subj. 22). The twin brother of this subject had died two years earlier, an occurrence which had obviously been very traumatic to her, for repeatedly during the testing the child made reference to her brother, or the fact that he had died. On time test three, which investigates the child's concept of age, she asserted that her mother, father, younger sister and herself did not get older each year. In support of her contention she gave the following reason, "Because none

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of us are every going to get old". It is clear in this case, that the child is not necessarily cognitively inadequate for the task, but that this response is related to an affect-laden event in the child's history. While this is only an isolated example, it seems of significance to record it, for it reveals strikingly the extent to which affective variables may influence cognition.

It is particularly interesting that this subject's protocols are indicative of a wide discrepancy between her capacity to conceptualize in the sphere of spatial cognition on the one hand, and her functioning on the time tests, on the other. Whereas the graphs representing the child's functioning on all three content areas (see Appendices), show clearly operational reasoning on all five space subtests, there is a very marked deviation from this level on her time tests. On the latter tests the child seems to be functioning at a significantly lower level. This finding strongly supports a suggestion made earlier that space cognition may be less susceptible to the effects of affective determinants than time, and hence more directly related to adequate cognitive experience and maturation of underlying brain structures. If both these conditions are provided, conceptualization in this sphere may readily occur. The marked discrepancy between the child's consistent operational functioning on the space tests, and her apparently pre-logical reasoning on four of the time tests, may perhaps be related to the greater propensity with which functioning on the time tests is susceptible to affective influences.

Another pointer to the possible effects of personality variables on cognitive development is to be found in the approach which different children adopted to the testing. Several subjects (eg. I.F., E.B., and A.F.) repeatedly enquired during the course of testing whether this was a "competition" or "exam." On the test protocol of subject A.F., the following has

been recorded. "I know you are bluffing me, and this is really a competition to see who is best". Other subjects asked for their marks, or enquired repeatedly of the tester whether the response was adequate. In the case of another subject (E.B.) repeated protestations were made as to the inadequacy of her functioning on these tests. It is certainly true that these tendencies were noted in only a small percentage of our sample group and that by far the majority accepted the test situation as a "game". However, even in these latter children subtle differences were noted. Some children approached the material carefully and deliberately, while others appeared to be clearly more impulsive, attacking the test material immediately and completing the task within a short period. The effects of these idiosyncratic personality variables would be strongly supported by the findings of McClelland and Atkinson, the general trend of whose work was discussed earlier. McClelland and Atkinson both found that children can be clearly delineated into two groups. Children with moderate need achievement scores are defensive and regard their inability to complete a task as a failure, as they become more ego-orientated. The achievement motivation of these children, then, appears to be oriented around avoiding failure. The child with the high need achievement score on the other hand, tends to regard the problem situation as a challenge and his motivation is oriented around the goal of attaining success. "It cannot be stated of course", says McClelland "which type of motivation is more efficient since either an excessive concern with avoiding failure or with success may be maladaptive depending on the requirements of the situation". (McClelland 1955 P.410) From the work of these authors, then, it seems perfectly possible that children may perform differently on the same cognitive task, and that this discrepancy relates not only to possible differences in the children's cognitive capacity,

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but also to such subtle motivational variables as McClelland et al, have considered.

One of the most interesting findings in this study relates to those results obtained on the fifth time test, devised to study conceptual development of subjective time. According to Piaget, the pre-operational child will estimate the times taken to draw the lines on the basis of perceptual cues alone. Thus, at the pre-conceptual level, the child will state that the longer line took a longer time to construct than the shorter line. These children fail to consider simultaneously a condition which was imposed, namely that the one set of lines was drawn quickly and the other set slowly. A point which has emerged from the protocols of many subjects in this group, and one which Piaget appears completely to have overlooked, is that the estimation of subjective time can also be related to the intensity of the work undertaken, and not only to the spatial cues provided by the different lengths of the lines. There appears to be a specific group of children who resort to one set of cues, and another clearly demarcated group who rely on the other. In addition, it appears from our results that those children who base their judgements on the intensity of the work undertaken are further subdivided into two clear-cut and distinctive groups. Children belonging to the first subgroup state that the "slower" set of lines takes longer to draw than the "quick" set. In the second subgroup children state just the reverse. The "quicker" lines, they claim, take longer to construct than the "slow" set. In this second group, it appears to be the intensity of the work, the greater muscular involvement and fatigue, which determines the judgement that the "quick" lines take longer time. In the first subgroup however, the dictum that time seems to "fly" when one works quickly and "drags" when one works slowly, seems chiefly to underlie the child's estimation of subjective time.

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In our opinion, these striking individual differences which have emerged from children in this group must relate to different personality factors, for it is difficult, if not impossible, to find a cognitive basis for this discrepancy. Furthermore, this finding is considered as a particularly interesting one, and a question that might well provide rewarding research. From our point of view this finding constitutes still further evidence for the possible influence of personality variables on the Piagetean tests, and for the extent to which they may account for discrepancies in one and the same protocol. Whereas it is clear in the case of those children who relate their time judgements to the length of the lines, that perceptual thought is still predominant over conceptual reasoning, one hesitates strongly before making any assumptions as to the level of cognitive development in the latter two subgroups. It seems well within the bounds of possibility that time estimations are affectively, as well as cognitively determined.

In concluding this brief survey on some of the possible sources of discrepancy in the test protocols on many subjects in the present sample, it may perhaps be proposed that the variables noted above mask the presence of a homogeneous intelligence characterized by clear-cut stages of development, and that these determinants may partly account for the discrepancy or inconsistency of functioning on tests devised to tap this homogeneous capacity. We may also suggest that further research give particular attention to the effects of these variables on cognitive development as measured by Piaget's tests. This research may prove to be particularly propitious to the sphere of time conception, and may well show that the pattern of cognitive development which Piaget proposes as a generalized rule applicable to every child, requires considerable amendment.

Having discussed the possible sources of

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deviation between test scores obtained by the individual child, it seems particularly necessary that a qualitative analysis of this nature incorporate a discussion of the general tone of cognitive reasoning which emerged from the test protocols of children in this study. Since Piaget's content books are rich in examples, and since he has been specifically concerned with the intricacies of the child's cognitive functioning, it is possible perhaps to draw some comparisons between our sample and the Piagetean group. Whereas we have attempted to relate discrepancies in test scores to extraneous factors, chance experiences and personality determinants, we now propose to consider the soundness of Piaget's theory of cognition per se.

It can be said in strong confirmation of Piaget's experimental findings that the intrinsic nature of responses made by the children on all the Piagetean tests administered in this study conform very closely to those which Piaget has recorded. It is particularly interesting to note that a fairly consistent thread of reasoning is found in the case of the pre-operational children on the one hand, and operational subjects on the other.

Common to most pre-operational responses is the close adherence to the perceptual characteristics of the stimulus situation. It is this which provides a consistent pattern underlying the bulk of the pre-logical responses and even accounts for an identical mode of reasoning in the case of many children. Correlative with this finding it was noted both in this study, and in Piaget's work, that a common trend was also clearly to be detected in the operational responses which the bulk of children gave on one and the same test. In all these tests it was noted that perceptual cues were considered as only secondary, and that conceptualization was directly related to the child's ability to co-ordinate a number of pertinent aspects relating to the situation on the basis of which adequate deductions were made.

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The consistent trend underlying the pre-operational responses to the extent that an identical response might be given by a large number of children on the same test, and likewise, the consistent pattern which has been noted in operational reasoning, we consider as one of the most important pointers in support of the tenability of Piaget's work on cognition. For if there is such consistency in the nature of the pre-operational responses on the one hand, and operational responses on the other, there may be considerable support for the idea that they constitute two clear levels of cognitive functioning, which correspond with different levels of maturation in the brain structures. Furthermore, it seems from results obtained in this study, and certainly from workers in the field of concept formation, such as Bruner (1964) and Harvey et al (1961), that this broad band of perceptual thought precedes conceptual reasoning. Observing Piaget's theory from this angle, it appears that there is much to be said in support of his theory of cognitive development.

In spite of this general support the problem which emerges is this:- How is this finding to be reconciled with the present results that at any one period in the child's life, both perceptual and conceptual reasoning prevail, even within the bounds of the same content area? There are many different explanations possible, and in the course of this discussion, we propose to put forward several suggestions.

Piaget has set out with the hypothesis that epistemological development occurs in fixed predetermined stages. From the protocols he obtained it appeared that perceptualization predominantly characterized the child's reasoning in subjects below the seven year level. The seven to eight year old period constituted a turning point, during which there was a general swing from perceptual to conceptual thought. To both perceptual and conceptual reasoning he was able to attribute independent and clearly definable qualities. The difficulty, however / ...

however appears to lie herein, that on the basis of this finding, Piaget has made a number of broad generalizations and interpretations. Since Piaget found that a band of perceptual reasoning generally preceded conceptualization, he hypothesized that intelligence was essentially a unitary capacity, underlying in a like manner every area of the child's intellectual functioning. Once the brain had evolved beyond a specific level, this development determined consistent cognitive functioning within one content area, and between one area and another. Thus, restated in terms of our hypothesis, there should be high intra-test reliability for any one child on the number, space and time batteries respectively, and a similarly significant inter-test reliability, since these all tap a unitary intellectual capacity. In the present study and in a similar one conducted by Dodwell (1960, 1962) on number tests, just the reverse has been found. If Piaget is correct, and there is much support for this point, that perceptual thought always precedes conceptualization in the course of the child's cognitive development, can the generalization be readily accepted that intelligence is a unitary capacity, which first underlies all perceptual reasoning in the child, and later, after additional maturation has taken place, determines the child's ability to conceptualize in every area of reasoning? Is it not possible, that this intellectual capacity is not a unitary one, that the child is capable of functioning in one area earlier than in another, and that in some areas his cognition is more adequate than in others? While perceptual thought always precedes conceptual reasoning, it might well be, that in some areas of cognitive functioning, conceptualization follows on perceptualization with greater rapidity than in other areas. This would relate directly to an uneven maturation in the brain structures of the child. While all brain structures appear to mature in a fixed and predetermined way allowing first for perceptual reasoning

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and only later for conceptual thought, the question arises as to whether there is simultaneous development in all brain structures giving rise to a unitary intelligence.

There is little doubt from the above point, and from a suggestion made earlier, that Piaget's theory may well be the victim of poor methodology and experimental procedure. Piaget's contentions follow on directly from his results, but it may well be queried whether his experimental procedure is, in fact, adequate to test the hypothesis set. Since this seems to be the most vulnerable point of Piaget's work, we may only suggest that his procedure be subjected to a vigorous reconstruction, and on the basis of this amendment, that his hypothesis be retested. This is not to say that Piaget's work has been in vain, for in its present form, it serves as an important pointer that this hypothesis may well warrant valuable research. The amendment, we suggest, should take the form of better standardization of the Piagetean tests to ensure their compatibility, a longitudinal study observing cognitive development in the same children over a span of several years, and replication studies on similar lines to that of the present one in order to determine the consistency of the child's functioning on different content areas at any one stage of development. Only a procedure along these lines can possibly be adequate to test the soundness of the Piagetean hypotheses.

c. Addendum.

As yet no reference has been made to Tables 11 12 and 13. This discussion has been reserved till the end for it serves to complement earlier analysis rather than directly validate or invalidate the major hypotheses we proposed to test. Since the results lend themselves to a simple statistical procedure, and in so doing, throw light on an important aspect of the Piagetean theory,

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a brief consideration may be included at this point.

One of the most important Piagetean hypotheses, and one which we attempted to test, is that intelligence is a unitary capacity, and that at the concrete operational stage, development is alike in all areas of intellectual functioning. In addition, and this is a point that is now considered, development appears to occur in broad bands or waves, alike for every child. The concrete operational stage might be set at the seven to eight year old period, although Piaget allows for wide individual variance. It is therefore to be expected that in a group of six to nine year old children there will be a progressive trend away from perceptual thought toward true conceptualization. This trend has been noted with hardly an exception by a large number of theorists, and on this basis, considerable support has accrued to Piaget's theory. In discussing these studies, we pointed out two reservations which must be made before we accept the saliency of these conclusions. In the first instance, it is only to be expected that as the child grows older, he becomes more efficient in solving a problem, whatever it's nature, and that he will eventually reach the age when he is capable of a complete and adequate solution on all Piagetean concept tests. In some children solution is reached earlier, dependent on any number of factors. The difficulty, however, is this. Provided that one finds a progression in scores with age, what support is there in these results that cognition develops in clear-cut sequential stages? What in fact constitutes a stage and what criterion can be accepted for adopting one or other "cutting point" in a series of scores? In the second instance it was pointed out that even if a clear-cut progression in scores is noted with increasing age when a battery of Piaget's tests is administered to a group of children, this gives us no insight into the relationship between independent test scores for an individual child.

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It is this latter point which constitutes a highly important consideration in Piaget's theory, and one which has been entirely concealed either by the experimental design or the statistical procedure employed in the great majority of replication studies. The computation of Tables 11, 12, and 13, and the results which have emerged from these we find of particular significance. While these results, in fact, clearly support the findings of many replication studies, that the ability to solve the Piagetean problems is a function of age, we know from Table 10, that there is frequently little intra-test realiability within one Piagetean content area, or between tests devised to study conceptual development in a number of different content areas. Similarly, the graphs drawn to represent independent test scores for individual children show that there is often little consistency between scores obtained on a battery of Piagetean tests. The fact, then, that a clear progression of test scores was found, even with gross underlying inconsistency in the pattern of scores obtained by an individual subject, cautions one against accepting as readily as one might, the relevance for Piaget's theory of many replication studies, which have employed a horizontal test design and a one-sided analysis.

Owing to the difficulties of assigning "stage" scores to the responses given by the children on the independent Piagetean tests, on the basis of Piaget's criteria, we adopted a purely quantitative form of scoring. However, simply and exclusively for the purpose of determining whether there is a clear progression of scores with age, it has been convenient to assign scores roughly to one of the three Piagetean substages. Thus, for example, on number subtest two, in which a possible total of ten marks can be obtained, children obtaining eight, nine or ten marks have been assigned to substage III, children obtaining six or seven points have been assigned to substage II, while children

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scoring below six have been rated as falling into sub-stage I. No authenticity is claimed for these rough demarcations, but for our present purpose the method is satisfactory, for it enables us to compare the four S groups on any one subtest. Thus, for example, the percentage of Group I children at "stages" one, two and three respectively, on number subtest two, can be compared with the percentage of group two children at these respective "stages" on the same subtest, and similarly such comparisons can be conducted with S groups three and four. However it is not permitted by this method to compare the percentage of children in any one group, and at any one substage on number test two, with the percentage of children in the same group, and at the same stage on number subtests three, four or five. The third stage for example on one subtest, may not correspond exactly with the third stage on another, using the above demarcations. For this reason in particular it was not possible to use "stage" scores in computing the degree of concordance between different subtest scores for the individual child.

Having assigned the scores of each child on a particular test to one of the three "stages", we proceeded to determine the percentage of children in S group one, at "stages" one, two and three respectively, on number subtest two. An identical analysis was conducted for S groups two, three and four on this subtest, and a similar computation was carried out for all the S groups on number subtests three, four and five, on all five space tests and on time subtests one, two, four and five. These results are recorded in Tables 11, 12 and 13. An analysis of this kind was omitted in the case of number subtest one and time subtest three, since it is clear from Table 1 a,b,c (raw score table) that the sample as a whole seems to be functioning at a level well in advance of the level of these tests, and hence no clear progression in performance on these tests with age, is likely to be noted.

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From Table 11, we note that on number test two, three and five, the progression is in line with what is expected. On number test two the percentage of children at the third "stage" increases steadily from group one to group four, so that whereas there are only 22% at the third stage in group one on this test, there are 75% in group four. Correlatively, the percentage of children at "stage" one decreases from group one to group four, so that 45% of the children in group one are at "stage" one, but none at all are found to function at this level in group four. Precisely the same trend is found in the case of number tests three and five.

In these results, then, there is staunch confirmation of what has been found in most of the Piagetean replication studies. The older groups in this study appear clearly to function at a superior level generally than the younger groups. On no account, however, is claim made that these results support Piaget's hypothesis of clear-cut stages of development, claims which have all too readily been staked in many replication studies. All that can be said is that there appears to be a progression in the level of functioning in the direction which Piaget claims. In addition, results on number subtests two, three and five show that the most marked differences exist between groups one and two (6 and 7 year olds), but that this discrepancy is not as marked between groups two, three and four. This would again confirm Piaget's view to some extent, that the significant shift from the pre-operational to the concrete operational stage occurs usually at the seven year level.

The progression from first "stage" to third "stage" responses between groups one and four is not as clearly discernible in the space tests (Table 12) as was found to be the case in the number tests. The shift towards operational thinking with increased age is clearly marked in space tests two and four and to a lesser extent in space test one. On the other hand it migt be considered as significant that there is a clear decrease between

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groups one and four in the percentage of first "stage" responses. This trend, however, is hardly discernible in the case of space test 3 where one notes that there are no children at all at "stage" one in S groups 2, 3 and 4 and only a small and insignificant percentage at this stage in S group I. Nevertheless from these results (Table 12), one can less easily detect a predominant shift from one group to the next on any of the tests. The progression appears to be more in the direction of a steady but slow increase than a sporadic shift between one group and the next.

From the results computed for the time tests (Table 13), there can again be noted a general trend of cognitive development in the direction which Piaget defines. With the exception of time test 2, there is an increase in the percentage of "stage" three responses as we move from group one to four, and a correlative decrease in "stage" one responses. On test two, however, one notes a fairly significant decrease in the "stage" three responses between groups three and four, a result which is contrary to what would be predicted by Piaget. Furthermore, on all these time tests we note, in particular, a significant decrease in the number of "stage" one responses between S groups one and two, and this is particularly predominant in the case of time tests four and five. In correspondence with this it is noted in each time test that there seems to be a fairly significant shift towards third "stage" responses between groups one and two, but a far lesser one between groups two, three and four. This is analogous to what was noted in the case of the number tests, that a predominant trend towards conceptualization appears to take place between the six and seven year old groups. These results then certainly confirm Piaget's contention that there appears to be a general progression towards true conceptual thought at the seven or eight year level, a hypothesis which has been successfully tested by many

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workers in the field of cognition.

While the latter results strongly support Piaget's contentions, that there is a trend of development in the direction which he stipulates, we know from an earlier analysis (Tables 10 and 9 and graphs) that there is often a gross inconsistency between test scores for our individual subjects, even within one and the same content area. In other words, an analysis conducted specifically to determine the percentage of "stage" one, two and three children at each age level would certainly have concealed a basic underlying tendency of inconsistency in their individual test patterns. It is this latter finding which provides such a serious objection to the concept of "stage" as outlined by Piaget.

This finding confirms a suspicion which arises repeatedly from a study of Piaget's work. It appears that Piaget has considered epistemological development from the normative point of view alone and on this account may well be guilty of a very gross over-generalization. Piaget has appeared to build a general theory, and attempted to apply a basic and general rule to the cognitive development of every child. In so doing, he has arrived at an implicitly neat and well-structured theory, but simultaneously, it is rigid, and lacks the flexibility to accommodate the variability and inconsistency characteristic of human behaviour.

It is interesting to note that this very characteristic of Piaget's work can readily be associated with his early training in biology and hence his basic orientation towards developmental epistemology. Piaget's basic interest throughout seems to be pivoted more on the structural organization underlying cognitive behaviour, than this behaviour itself. Although this is a subtle point, and one that Piaget himself has not acknowledged, the basic form of Piaget's cognitive theory, his principles of assimilation and accommodation, and the adaptive character which he considers fundamental

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to intelligence, all point to the strong biological orientation which he has adopted to the study of cognition. It is clear that a theoretical analysis of the structural organization underlying intelligence is strongly suggestive of a development in clear-cut sequential stages alike for every child. The sporadic maturation of brain structures, and the modification of these by external stimuli only subsequent to such maturation, is strongly indicative of the course of development which Piaget propounds as a general rule applicable to every child. It seems, then, that the fundamental core of difficulty in Piaget's theory relates to his over-dependence on the purely structural organization of behaviour, and his failure to study, adequately, behaviour per se. In drawing a direct analogy between structural organisation on the one hand, and behavioural organisation on the other, he has attributed to cognition the perfect and clear-cut patterning which theoretically we may attribute to its structural development. It is this very point which may account for Piaget's failure to give sufficient attention to such influences on cognitive development as personality organization, the child's present emotional state, training effects, situational and test variables or miscellaneous experiences.

However, to discredit Piaget's theory without the support of further replication studies and research is to adopt an inimicable stand which is perhaps unjustified. Rather we may suggest that further research be devoted to a study of the child's cognitive behaviour itself and that for this purpose in particular, adequate test designs and statistical procedures be instituted. Only carefully conducted studies on cognition at this level can possibly show to what extent the direct analogy which Piaget has drawn between structural patterning and cognitive behaviour, is a valid one.

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VIII. IMPLICATIONS FOR FURTHER RESEARCH.

In an attempt to determine whether the child's cognitive functioning is significantly homogeneous within one area, either of number, space or time, and whether such stability of functioning is maintained over a number of content areas, several interesting points have emerged which suggest rewarding research if followed up.

1. From the present study, it was possible to conclude that the five Piagetean space tests selected appear to tap a more consistent level of functioning in children comprising the differently constituted subgroups than do the number tests, and a similar tendency, though not as marked, was found in comparing the space and time tests. At that point it was suggested that this may be attributable to the closer link between sensory-motor activity and spatial conceptualization than between time or number conception and sensory-motor activity. It follows from this finding that fruitful research might stem from an investigation of the relationship between results obtained on a representative sample of Piagetean time, number and space tests, when administered to a group of maternally deprived children. If a significant difference is found between the space tests on the one hand, and the time and number tests on the other, when administered to this group, there may be much support to substantiate the idea that spatial conceptualization is significantly less related to personality determinants, than is the child's conception of number and time.

2. A second research project which was suggested earlier, and which may be considered in broader detail at this point, relates to an investigation of the child's subjective time. It was noted from results obtained on the fifth time test by children in the present sample, that two clearly delineated groups emerged. This test tapped

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the child's ability to judge the duration of her own actions when drawing two sets of lines, one quickly the other slowly, over two identical time periods. In the case of the one group, time estimation was related to the perceptual cues provided by the situation (length of lines), in the other, estimation was apparently related to the intensity of the work. However a point which was noted to be of particular significance is that the latter group was again clearly subdivided. Whereas children in the one subgroup stated that the "quicker" lines took longer to draw, children in the second group stated just the reverse, that the "quicker" lines took less time to construct than the alternative set. This marked distinction between children could not be related to any cognitive determinant. It is possible, though, that this discrepancy relates to the effects of personality variables. A series of personality scales may therefore be administered to a group of subjects in order to investigate whether individual differences, as noted above, relate to idiosyncratic personality determinants.

3. A further possible research project suggested by our results, relates to a finding which was recorded from the small group of nine year old subjects in this study. It was clear that the concrete operational stage, as defined by Piaget, had been attained in both number and space conceptualization by the great majority in the group. However, on the time tests gross discrepancies in functioning were still noted from the protocols of these children. This suggests that in general, conceptualization in some areas may develop earlier than in others. An interesting research project might be undertaken to confirm this trend and to determine whether development follows a closely parallel course in all areas of cognition as Piaget has outlined.

4. From the present study there also emerged a clear necessity for better standardization of the Piagetean tests.

Test protocols show that some tests may be basically easier than others, for the sample as a whole. Valuable research may therefore be undertaken to determine whether the operations underlying each test, and hence the tests themselves, are of equal complexity. It is obviously of prime importance in determining whether the child has attained a particular "stage" of development in the Piagetean sense, that the tests administered are parallel measures of cognitive functioning. Only further research can throw light on this question.

5. The results of the present study suggest that the effects of affective variable on cognition may well mask a clear-cut pattern of stages in development. Theoretically, time cognition is the most susceptible to these effects. An interesting research project might be undertaken to determine whether one and the same child functions consistently on the Piagetean tests of subjective time on the one hand, and those of objective time on the other. At the concrete operational stage, Piaget claims that certain operations develop simultaneously in the child, and to tap such operations tests of subjective and physical time have been devised. The difference between subjective and physical time according to Piaget, lies herein, that the former relates to some event or action with which the child is directly or indirectly involved, whereas the latter refers to a particular event which has no direct or personal bearing on the subject. Both the development of subjective and physical time pass through three clearly defined stages, and development in both areas is more or less parallel. However it may be surmised from the trend of results in this study, that the child's conception of subjective time is more affected by personality variables than her concept of physical time. Piaget has devised several tests to tap the child's cognition in both areas. These tests are all solvable at the concrete operational stage. It follows, then, that a substantial battery of tests can be put together for the

purpose / ...

purpose of such a study. Provided that a significant difference is found, we may have further evidence that personality determinants, particularly within the sphere of time conception, affect cognition to a greater extent than Piaget has made provision for in his theory.

6. A final suggestion for further study, and one we admit, that is easier to propose than to actually conduct, is a longitudinal research procedure in order to determine whether development in clear-cut stages, and in the sequence which Piaget suggests, is found to be the norm. This is perhaps the only valid method to determine whether the three stages which Piaget has hypothesized, emerge in the order which he stipulates, and furthermore whether this development can be taken as a generalized case for all human beings. However even if we propose to consider only the sensory-motor, intuitive, and the concrete operational stages, the individual must be studied over a time span ranging from at least a year to seven or eight, and the practical difficulties involved in such a study are sufficient to ward off any potential research. But if such a study is undertaken by a team rather than the individual research worker, it may be the only veridical method to determine whether cognition follows the pattern Piaget has stipulated.

Several implications follow from a study of this kind. We may be able to establish from this testing programme whether in fact, there are different "cognitive types". By this we imply that some children may be more cognitively stable than others, and that this tendency is marked throughout the course of cognitive development. At each potential stage, inconsistency would be more characteristic of the cognitive functioning of these children than of their contemporaries. It may well be the case that cognitive instability in children is as marked a feature as emotional instability. If something analogous to cognitive instability, can be determined in

children, there may be considerable need for reconstructing Piaget's theory of fixed stages alike for every child.

In the second place, a research programme of this nature may be of particular significance in validating Piaget's work on sensory-motor intelligence on the one hand, and his theoretical contentions appertaining to concrete operational intelligence on the other. In our opinion the six substages which Piaget claims are characteristic of sensory-motor intelligence may emerge more clearly and be more generally applicable than those characteristic of the concrete operational stage. For at the first or sensory-motor stage, personality variables, or chance experiences, may less easily mask a clear pattern of cognitive functioning. Hence the extent of individual differences and variation may be significantly reduced. In other words there may be a more immediate link between structural organization and cognitive organization at the sensory-motor stage than at the stage of concrete operations.

We have considered briefly the most pertinent research projects suggested by our study. While these relate to many different facets of Piaget's theory, it is possible that many, as yet clandestine features of Piaget's theory, may come to light, if these are adequately followed up.

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IX. CONCLUSIONS.

On the grounds of the foregoing discussion, several conclusions can be drawn and related to our two major hypotheses:-

(1) Following from results obtained in this study we can conclude that consistency of cognitive functioning within the area of number and time conception does not appear to be the case in the great majority of children in the sample. This inconsistency seems especially marked in the number protocols, a trend which is substantiated by the non-significant Coefficient of Concordance values computed for these tests. On the other hand, the Coefficients of Concordance and the graphs presented suggest a stronger disposition in our group towards consistency of cognitive functioning on the five Piagetean space tests selected, although this is by no means a generalized case. This latter tendency may perhaps relate to the closer link between sensory-motor activity and spatial conceptualization than is necessarily the case with number and time cognition. From the results obtained it appears that particularly in the sphere of time conception, personality determinants may account for inconsistencies in test patterns recorded.

(2) The "W" values computed for the A and S groups (Age and Standard groups) also present a serious objection to our second major hypothesis. With the exception of S group three, there appears to be a significant degree of inter-test variability between number, space and time batteries, when administered to the differently constituted groups in our study. It may then be concluded that with few exceptions, no general level of functioning can be computed for an individual child in any one content area, nor does there appear to be a typical or universal level at which she

functions / ...

functions in the three content areas of number, time and space. From the computation of "W" values, it also appears to be the case that when children are subdivided on the basis of school standard, the independent subgroups so constituted tend to respond more homogeneously particularly on time and space tests than children subdivided exclusively on the basis of age. The school experience common to each child in the former groups may partly contribute to this finding.

(3) On the basis of the present study we may also conclude that pre-logical responses on the one hand and operational responses on the other have clearly definable qualities of their own, and constitute two specific planes of thought. This is in strong confirmation of Piaget. However, from the graphs presented the raw score data, and "W" values computed, we cannot accept that the child's reasoning in all areas is determined by perceptualization at one level of development and by conceptualization at the next. It may only be concluded that conceptualization may follow on perceptualization in some area of cognitive functioning with greater rapidity than in others. In other words we failed to detect the operation of a homogeneous intelligence which Piaget postulates.

(4) A further interesting conclusion to be drawn from this study is that there is a general trend of development in the direction which Piaget predicts. From the computation of "stage" I, II, and III responses for each of our four S groups on the 15 Piagetean tests administered there appears to be a clear progression in the percentage of "stage" III responses obtained with age, and a correlative decrease in the percentage of "stage" I responses. However, in relating this finding to our earlier conclusions that intra- and inter-test variability seems predominantly to characterize the test protocols of individual children in our sample, we can only conclude, that an analysis of this kind as used by Piaget himself, and as

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found in the majority of replication studies, sounds a strong note of warning against accepting the contention of clear-cut stages of development and a homogeneous intelligence exclusively on the basis of such a statistical procedure.

(5) Finally, we may conclude, that Piaget's contentions of a homogeneous intelligence, and the related idea of fixed stages of development, may in part, be determined by the poor methodology Piaget has employed, the inclination on his part to consider human development from the "normative" point of view, and finally his tendency to draw too direct or immediate an analogy between the theoretical model appertaining to the structural organization of the brain on the one hand, and the behavioural organization of the child on the other.

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SUMMARY:

This study, conducted on fifty eight school girls, aged six to nine years, was undertaken to validate two major hypotheses deriving from Jean Piaget's theory of cognitive development. The first stated as follows:- The child at the concrete operational stage functions at a consistent or homogeneous level within any one area of cognition, either of number, space or time. The second major hypothesis was framed as follows:- A general level of cognitive functioning may be established at which each child responds on all three areas of number, space and time. The level at which the child responds within one content area, is therefore identical to the level of functioning which characterizes his cognition within other areas.

Five tests each, were selected from Piaget's books on the development of number (1952), space (1956), and time concepts (1955), and these, constituting three independent batteries, were administered to each child on three testing sessions.

Three statistical procedures were employed in the analysis of results. By means of Kendall's Coefficient of Concordance "W", we attempted to note the intra- and inter-test reliability between tests administered to the differently constituted groups. Children were delineated on the basis of school standard and age. Secondly graphs were drawn to represent the scores of seventeen randomly selected subjects, chosen from each of the age groups. Finally the percentage of "stage" I, II and III children at each age level, and on each of the fifteen subtests, was calculated. In considering the results, a purely qualitative analysis, was also undertaken.

From the results, we were able to conclude, that consistency of cognitive functioning within one content area or between one area and another, was not predominantly

found / ...

found in our sample. Children may be at one Piagetean stage of development, for one test situation, and at a different stage for another situation, at one and the same time. It was therefore not possible to compute a general level at which any one child functioned. However, there was a significant tendency for children to respond more consistently on the space tests, than on the number and time tests. Finally, on the basis of the "stage" scores computed, we were able to conclude that there is a general progression of cognitive development with age in the direction which Piaget advocates.

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BIBLIOGRAPHY.

1. Ames L.B. The development of the sense of time in the young child. The Journal of Genetic Psychology 1946, 68, 97-125.

2. Ausubel D.P. Theory and Problems of Child development. New York; Gruner and Strattan 1958.

3. Beilin H and Franklin I. Logical operations in area and length measurement; Age and training effects. Child Development 1962, 33, 607-618.

4. Berlyne D.E. Recent development in Piaget's work British Journal of Educational Psychology 1957, 27 Part 1, 1-12.

5. Blair Hood H. An experimental study of Piaget's theory of the development of number in children. British Journal of Psychology 1962, 53, No. 3, 273-286.

6. Bradley N.C. The growth of the knowledge of time in children of school age. The British Journal of Psychology 1947-1948, 38, 67-78.

7. Bruner J., Goodnow J., Austin G. A study of Thinking - New York. John Wiley and Sons Inc. 1956.

8. Bruner J., Inhelder and Piaget. The growth of logical thinking. I. A psychologist's viewpoint. British Journal of Psychology 1959, 50 Part 4, 363-370.

9. Bruner J. The course of cognitive growth - American Psychologist. Jan. 1964, 19, No. 1., 1-16.

- - - - -

10. Brunswik E. Scope and aspects of the cognitive problem - "Cognition": The Colorado Symposium. Harvard University Press Cambridge 1957.

11. Chambers D. Maternal Deprivation and concepts of time in children. American Journal of Orthopsychiatry 1961, 31, 406-419.

12. Churchill E. The number concepts of the young child: Part I - Researches and Studies. Leed's University 1958, 17, 34-39.

13. Churchill E. The number concepts of the young child: Part II - Researches and Studies. Leed's University. 1958, 18, 28-46.

14. Cowley J.J., and Murray M. Some aspects of the development of spatial concepts in Zulu children - Journal for Social Research 1962, 13, 1-8.

15. Dodwell P.C. The evolution of number concepts in the child - Mathematical Teaching. 1957, 5, 4-9.

16. Dodwell P.C. Children's understanding of Number and related concepts - Canadian Journal of Psychology 1960, 14, 191-205.

17. Dodwell P.C. Children's understanding of number concepts - Characteristics of an individual and group test - Canadian Journal of Psychology 1961, 15, 29-36.

18. Elkind D. Children's discovery of the conservation of mass, weight, and volume: Piaget's Replication Study II - Journal of Genetic Psychology 1961, 98, 219-227 (a).

19. Elkind D. Quantity conception in junior and senior high school students. Child Development 1961, 32, 551-560 (b).

20. Elkind D. The development of additive composition of classes in the child: Piaget Replication Study III - The Journal of Genetic Psychology 1961, 91, 51-57 (c).

21. Elkind D. The development of quantitative thinking: A systematic replication of Piaget's studies - Journal of Genetic Psychology 1961, 68, 37-46 (d).

22. Elkind D. and Scott L. Studies in perceptual development - Child Development 1962, 33, 619-630.

23. Ervin S.M. Training and a logical operation by children. Child Development 1960, 31, 555-564.

24. Flavell J.H. The developmental psychology of Jean Piaget. New York: D. Van Nostrand Company Inc. 1963.

25. Goodnow J.J. A test for milieu effects with some of Piaget's tasks - Psychological Monographs 1962, 76, No. 36.

26. Harvey O.J., Hunt D., Schroder H. Conceptual Systems and personality organization - New York - John Wiley and Sons Inc. 1961.

27. Hoch P. and Zubin J. Psychopathology of Childhood - New York. Gruner and Stratton 1955, pp. 34-46.

28. Hunt, McV. Intelligence and Experience - New York. The Ronald Press Co. 1961.

29. Inhelder B and Piaget J. The growth of logical thinking from childhood to adolescence U.S.A.. Basic Books Inc. 1958.

30. Jersild A. Child Psychology (Third Edition) London: Staples Press Limited 1947. pp. 321-416.

31. Kohstamm G.A. An evaluation of part of Piaget's theory - Acta Psychologica 1963, 21, No. 4/5, 313-356.

32. L'Abate L. Consensus of Choice among children A test of Piaget's theory of cognitive development - The Journal of Genetic Psychopathology 1962, 100, 143-149.

33. Lindquist E.F. Design and Analysis of Experiments in Psychology and Education - Cambridge Riverside Press 1953.

34. Lovell K. A follow-up study of some aspects of the work of Piaget and Inhelder on the child's conception of space - British Journal of Educational Psychology 1959, 29, 104-117.

35. Lovell K. and Slater A. The growth of the concept of time: A comparative study. The Journal of Child Psychology and Psychiatry 1960, 1, No. 3, 179-190 (a).

36. Lovell K and Ogilvie E. A study of the conservation of substance in the junior school child. The British Journal of Educational Psychology 1960, 30, Part 2, 109-118.

37. Lunzer E.A. "A pilot study for a quantitative investigation of Jean Piaget's original work on concept formation" - a footnote. Educational Review 1956, 8, 193-200.

38. Lunzer E.A. Some points of Piagetean theory in the light of experimental criticism. Journal of Child Psychology and Psychiatry, 1960, 1, 191-202.

39. McClelland D. Studies in motivation - Appleton Century Crofts Inc. - New York 1955.

40. Müller P. Contemporary psychology in Switzerland. Acta Psychologica 1961, 18, 29-47.

41. Oakden E.C. and Sturt M. The development of the knowledge of time in children. The British Journal of Psychology 1922. 12, Part 4 309-336.

42. Orme J.E. Time studies in Abnormal and Normal personalities - Acta Psychologica 1962, 20, pp. 285-303.

43. Peel E.A. Experimental examination of some of Piaget's schemata concerning children's perception and thinking and a discussion of their educational significance - The British Journal of Educational Psychology, 1959, 29, Part II, 89-107.

44. Piaget J. The Language and Thought of the Child. London. Kegan Paul, Trench, Trubner & Co. Ltd. 1926.

45. Piaget J. The Child's conception of the world. New York: Harcourt + Brace 1929.

46. Piaget J. Child's conception of Physical causality London : Kegan Paul 1930.

47. Piaget J. The Psychology of Intelligence - New York, Harcourt, Brace - 1950.

48. Piaget J. The Biological Problem of Intelligence. In D. Rapaport's "Organization and Pathology of Thought". New York. Columbia University Press 1951 (pp. 176-186) (a).

49. Piaget J. Principal factors determing intellectual evolution from childhood to adult life. In. D. Rapaport's "Organization and Pathology of Thought". New York. Columbia University Press 1951. (pp. 154-171).

50. Piaget J. The child's conception of number - London. Routledge and Kegan Paul Ltd. 1952.

51. Piaget J. The child's construction of Reality - New York. Basic Books 1954 pp. 320-350.

52. Piaget J. Die Bildung des Zeitbegriffs beim Kinde. Zürich. Rascher & Cie. A.G. 1955 (a).

53. Piaget J. Perceptual and cognitive structures in the development of the concept of space in the child - Acta Psychologica 1955, 11, 41-46 (b).

54. Piaget J. The development of time concepts in the child. In Hoch P. and Zubin J. "Psychopathology of childhood" - New York. Gruner and Stratton 1955, pp. 34-46 (c).

55. Piaget J. and Inhelder B. The child's conception of space: London - Routledge and Kegan Paul 1956.

56. Price-Williams D.R. A study concerning concepts of conservation of quantities among primitive children - Acta Psychologica 1961, 18, 297-305.

57. Rapaport D. Organization and Pathology of thought. New York. Columbia University Press. pp. 154-186.

58. Sackett G. A neural mechanism underlying unlearned critical periods and developmental aspects of visually controlled behaviour. Psychological Review. 1963, 70, No. 1, 40-51.

59. Schechter D., Symonds M., Bernstein J. Development of concepts of time in children - Journal of Nervous and Mental Disease, 1955, 121, pp. 301-310.

60. Siegel S. Nonparametric statistics for the behavioural sciences. New York - McGraw Hill Book Company Inc. 1956.

61. Smedslund J. Development of Concrete transitivity of length in Children - Child Development 1963, 34, No. 2, 389-405.

62. Smedslund J. The acquisition of transitivity of weight in five to seven year old children. The Journal of Genetic Psychology 1963, 102, 245-255.

63. Smedslund J. The effect of observation on children's representation of the spatial orientation of a water surface. Journal of Genetic Psychology 1963, 102, 195-201.

64. Smoke K. An objective study of Concept Formation. The Psychological Monographs 1931 - 1932, 42, No. 191.

65. Vurpillot E. Piaget's law of relative centrations - Acta Psychologica 1959, 16, 403 - 428.

66. Werner H. Comparitive Psychology of Mental Development. U.S.A. Harper and Brothers Publishers 1940.

67. Wohlwill J.F. A study of the development of number concepts by Scalogram Analysis. Journal of Genetic Psychology 1960, 97, 345-377.

68. Yudin L. and Kates S.L. Concept attainment and adolescent development - Journal of Educational Psychology 1963, 54, No. 4, 177-182.

Secondary Sources

69. Piaget J. Etudes d'epistemologie genetique Vol.3 Paris Presses Univ. France 1958. In Müller P. Contemporary Psychology in Switzerland. Acta Psychologica 1961, 18, 29-47.

Appendices:

A scoring schedule for the Piagetean number, space and time tests as devised for the present study is first presented.

The following tables are also contained in the appendices:-

Tables 14-34: These constitute the standard score and KxN tables required for the computation of "W" values, for S groups one to four on number, space and time tests.

Tables 35-51: These constitute the standard score and KxN tables required for the computation of "W" values for A groups (A_1 - C_2) on number, space and time tests.

In addition the appendices contain 17 graphs drawn to represent the performance on number, space, and time tests of seventeen randomly selected subjects. Four graphs are representative of children in the Sub B, Standard I and Standard II classes respectively. From the Sub A group, five children are represented.

The graphs follow in this sequence:-

Sub A Group	- E.F., C.H., H.B., P.A., G.Q.
Sub B Group	- K.R., R.S., G.S., P.G.
Standard I Group	- Jv.A., M.W., D.H., Kyd.M.
Standard II Group	- T.J., E.B., F.D., L.L.

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Scoring Schedule

1. Number tests

Test one :- Conservation of continuous quantities.

	Score	Maximum Score on Test
(a) Correct correspondence between glasses and bottles.	1	
Correspondence between glasses and bottles (bottles grouped)	1	
Correspondence between glasses and bottles (glasses grouped)	1	
(b) Correct correspence between red flowers and vases.	1	
Correspondence between red flowers and vases (flowers bunched).	1	
Correspondence between red flowers and vases (vases bunched).	1	
(c) Correspondence between number of red and blue flowers.	1	
		7

Test two :- The test of seriation, qualitative similarity and ordinal correspondence.

Section I

Correct seriation of dolls.	3
Seriation of dolls with trial and error.	2
Seriation of dolls with one reversal.	2
Seriation of dolls with one reversal and trial and error.	1
Seriation of dolls with two reversals.	1

Section II

Correct insertion of sticks.	3
Insertion of sticks with trial and error.	2
Insertion of sticks with one reversal.	2
Insertion of sticks with one reversal and trial and error.	1
Insertion of sticks with two reversals.	1

Section III

Dolls Grouped:-

(a) correct choice of corresponding doll when tester points to stick.	1

	Score	Maximum Score on Test
(b) Correct choice of corresponding stick when tester points to doll.	1	
Dolls Reversed:-		
(a) Correct choice of corresponding doll when tester points to stick.	1	
(b) Correct choice of corresponding stick when tester points to doll.	1	
		10
Test three :- Ordination and cardination		
Section I		
Correct seriation of sticks.	3	
Correct seriation of sticks with trial and error.	2	
Seriation of sticks with one reversal.	2	
Seriation of sticks with one reversal and trial and error.	1	
Seriation of sticks with two reversals.	1	
Section II		
Correct insertion of sticks in "staircase"	3	
Insertion of sticks with trial and error.	2	
Insertion of sticks with one reversal.	2	
Insertion of sticks with one reversal and trail and error.	1	
Insertion of sticks with two reversals.	1	
Section III		
(a) Correct number of stairs behind doll.	2	
(b) Correct number of stairs doll has climbed.	2	
(c) Correct number of stairs doll must still climb to reach top of staircase	2	
		12
In the case of the child who confuses number of stairs already climbed with those still to be climbed, one point each is scored on questions b and c.		

	Score	Maximum Score on Test.
Test four :- The test of additive composition of classes.		
Section I.		
(a) Correct answer to question:- Are there more glass beads or more yellow beads in box.	1	
Correct Reasoning.	1	
(b) Correct answer to question:- Will necklace with glass or yellow beads be longer.	1	
Correct Reasoning.	1	
(c) Correct answer to subsidiary questions:- When yellow beads taken out of box will there be any beads left in box.	1	
If glass beads taken out of box, will there be any beads left in box.	1	
Section II.		
Correct answer to question:- Are there more girls or more children on card.	1	
Correct reasoning.	1	
		8
Test five :- The test of additive composition of numbers and arithmetical relations of part to whole.		
(a) Correct correspondence between beans obtained "today" and "tomorrow".	2	
Correct Reasoning.	1	
(b) Correct equalization of beans placed in two piles (six in one, four in the other).	1	
Correct Reasoning.	1	
(c) Correct division of beans when presented in a single pile of fourteen.	1	
Correct Reasoning.	1	
		7

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	Score	Maximum Score on Test
II. SPACE TESTS.		
Test one :- The test of perceptual and representational space.		
Thirteen euclidean and topological shapes presented, one point for each correct identification.	13	13
Test two :- The treatment of elementary Spatial relations.		
Eleven topological and euclidean figures presented to each child. The marking schedule for this test is as follows:-		
Two marks for each correct drawing. One mark if not more than one error, or two errors symmetrically executed eg. Rectangle drawn as a square. In the case of shapes involving curves, two marks if fairly true to shape, one mark if it can be clearly recognized as say circle or ellipse.		
In case of figure where two drawings have to be executed one in relation to the other, four marks are assigned, i.e. two for each figure. In addition to these four marks, an additional mark is allotted if the two figures are in the correct relationship to each other, eg. three points of triangle touching circumference of circle.		33
Test three :- Linear and circular order.		
(a) Correct representation of linear order.	2	
Representation of linear order with trial and error.	1	
Representation of linear order with one reversal.	1	
(b) Correct representation of reversed linear order.	2	
Representation of reversed linear order with trial and error.	1	
Representation of reversed linear order with one reversal.	1	

	Score	Maximum Score on Test
(c) Correct representation of circular order.	2	
Representation of circular order with trial and error.	1	
Representation of circular order with one reversal.	1	
(d) Correct representation of figure of eight.	2	
Representation of figure of eight with trial and error.	1	
Representation of figure of eight with one reversal.	1	8
Test four :- The test of projective lines and perspective.		
Section I.		
Sticks correctly placed in perspective along straight edge of rectangular table.	2	
One stick out of line.	1	
Section II.		
Sticks correctly placed in perspective when two end poles placed midway along adjacent sides of rectangular table.	2	
One or two sticks out of line.	1	
Section III.		
Correct placement of sticks in perspective when two end poles placed at different points on circumference of cardboard round.	2	
One or two posts out of line.	1	
Ability to "take aim" on own accord (or choose point from which lines seen in true perspective).	2	
Ability to "take aim" when prompted by tester.	1	
Section IV.		
Correction of zig zag line of poles to form a projective straight line.	2	
One pole out of line.	1	
Ability to "take aim" of own accord (or choose point from which lines seen in true perspective).	2	
Ability to "take aim" when prompted by tester.	1	12

	Score	Maximum Score on Test
Test five :- The test of affinitive transormations of the rhombus and conservation of parallels.		
Section I.		
Ability to conceptualize transformation of the rhombus and so stipulate changes that occur in both length and width of figure.	2	
Ability to conceptualize transformation of the rhombus but stipulate changes only in one dimension i.e. length or width.	1	
Section II.		
Perfect representation of four rhombuses (i.e. correct progression in size plus rhombus correctly drawn with opposite sides parallel and four sides equal in length).	3	
Representation of four rhombuses showing correct progression in size but rhombus incorrect in one aspect i.e. either failure to conserve length of sides, or opposite sides not perfectly parallel.	2	
Correct representation of rhombuses (i.e. sides parallel and of equal length) but showing one reversal in size progression of the series.	2	
Correct progression in size of figures represented, but rhombus presented as square or rectangle.	1	
Correct representation of rhombus i.e. sides parallel and of equal length but showing increase in width instead of increase in length of figure.	1	
Correct presentation of rhombus (i.e. sides parallel and of equal length) but complete failure to show progression in size.	1	
Inability to show correct progression in size plus complete failure to represent rhombus correctly.	0	
		5

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	Score	Maximum Score on Test
III. TIME TESTS.		
Test one :- The test of duration of intervals.		
Section I.		
(a) Ability to state that synchronous time intervals ($I_1 - I_2$) and ($II_1 - II_2$) are equal (plus correct reason.	1	
(b) Ability to state that synchronous time intervals ($I_1 - I_5$) and ($II_1 - II_5$) are equal (plus correct reason).	1	
(c) Ability to state that synchronous time intervals ($I_1 - I_3$) and ($II_1 - II_3$) are equal (plus correct reasoning).	1	
(d) Statement that asynchronous time intervals ($I_1 - I_3$) and ($II_1 - II_2$) are unequal.	1	
Correct reason.	1	
(e) Statement that time interval ($I_1 - I_2$) equals interval ($I_2 - I_3$).	1	
Correct reason.	1	
(f) Ability to state correctly whether water takes more or less or same time to go down in measuring cylinder or rise in beaker (plus correct reason).	1	
Section II.		
Correct seriation of D_1 cards.	3	
Seriation of D_1 cards with one reversal.	2	
Seriation of D_1 cards with two reversals.	1	
Correct seriation of D_2 cards.	4	
Seriation of D_2 cards with one reversal.	3	
Seriation of D_2 cards with two reversals.	2	
Seriation of D_2 cards with three reversals.	1	
		15

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	Score	Maximum Score on Test
Test two :- The test of synchronous time intervals.		
Section I.		
Dog placed 2" ahead of rabbit:-		
(a) Statement of simultaneity of starting times.	1	
Correct reason.	1	
(b) Statement of simultaneity of stopping times.	1	
Correct reason.	1	
(c) Ability to state whether both dog and rabbit stopped at lunch.	1	
Correct reason.	1	
(d) Ability to stipulate whether running times of two objects identical.	1	
Correct reason.	1	
(e) Correct answer to question: If dog ran for two minutes how long did rabbit run for?.	1	
Section II.		
Starting positions of dog and rabbit identical:-		
(a) Statement of simultaneity of starting times.	1	
Correct reason.	1	
(b) Statement of simultaneity of stopping times.	1	
Correct reason.	1	
(c) Ability to stipulate whether running times of two objects identical.	1	
Correct reason.	1	
		15
Test three :- A test to investigate the child's concept of age (Test I).		
10 questions asked. One point for each correct answer.		10

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	Score	Maximum Score on Test
Test four :- A test to investigate the child's concept of age (Test 2).		
Section I.		
(a) Statement that ages of elm and oak tree cannot be determined.	1	
Correct reason to substantiate statement.	1	
Alternatively:-		
(b) Statement that trees identical in age.	1	
Reason to substantiate this answer by reference to date of planting.	1	
(c) Correct statement that short tree sometimes older than tall one.	1	
Correct reasoning.	1	
Section II.		
(a) Seriation of apple trees.	2	
Seriation of apple trees with one reversal.	1	
(b) Seriation of pear trees	2	
Seriation of pear trees with one reversal.	1	
(c) Correct answer to question: "Which tree is older, apple or pear."	1	
Correct reason.	1	
(d) Correct correspondence between apple and pear trees (plus correct reason in each case) at:-		
(i) two year level.	2	
(ii) three year level.	2	
(e) Ability to discriminate ages of apple and pear trees (plus correct reason in each case), when:		
(i) pear tree (2 yrs) and apple (3 yrs.)	2	
(ii) pear tree (6 yrs) and apple (7 yrs.)	2	
(f) Ability to answer following:-		
Which is oldest tree of all.	1	
Correct reason.	1	
Which is youngest tree of all.	1	
Correct reason.	1	
Section III.		
(a) Ability to state that apple and peach trees, same age.	1	
Correct reasoning (reference to birth order)	1	

	Score	Maximum Score on Test
Correct reasoning (reference to birth order plus explanation for larger number of fruit on peach tree e.g. more apples have been picked).	1	
Alternatively:		
(b) Statement that ages cannot be determined	1	
Demand for further criteria in order to determine age.	1	
Demand for further criteria plus explanation for larger number of fruit on peach tree in relation to apple.	1	
		25
Test five :- A test which taps child's ability to judge duration of his own actions.		
(a) Ability to state that both lines took equal time to draw plus explanation that one series drawn quicker and hence its greater length in relation to the other.	9	
(b) Statement that one of the two series (either "quick" or "slow" lines) took longer to draw. In explaining the relationship in length, of one line to the other, reference must be made to speed with which lines were drawn.	6	
(c) Statement that one line took longer to draw than the other. As reason for this the child refers to the perceptual cues of the stimulus configuration (i.e. greater length of one line in relation to other).	3	
		9

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TABLE 14

STANDARD SCORES OBTAINED ON NUMBER TESTS TWO TO FIVE : S GROUP I (SUBJECTS 15-36)

	SUBJECTS																				
NUMBER TESTS	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
2	-1.63	- .05	-1.10	- .57	-1.10	.47	1.00	- .05	- .57	1.00	- .57	.47	1.52	-1.10	-1.10	-1.63	-2.15	- .05	-1.63	- .05	-1.10	-1.10
3	.28	- .19	-1.14	- .19	- .66	-1.14	- .66	- .19	.28	.28	-1.61	.76	-1.14	-1.14	-1.14	- .66	-1.61	-2.09	1.71	- .66	-2.09	.28
4	-1.00	1.91	1.5	- .58	- .58	-1.00	- .58	.25	- .58	-1.0	- .58	- .58	.25	1.91	-1.00	- .58	-1.00	-1.00	-1.00	-1.00	.25	- .16
5	-1.00	-1.0	.25	- .37	.25	-1.00	-2.25	-1.62	-1.0	-1.62	-1.62	.87	.87	- 1.0	-1.00	- .10	- .37	-1.00	-2.25	-1.0	-1.0	-1.0

TABLE 15.

KxN TABLE :- RANKINGS FOR S GROUP I ON NUMBER TESTS.

SUBJECTS

NUMBER TESTS	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
2	20	7.5	15.5	11	15.5	4.5	2.5	7.5	11	2.5	11	4.5	1	15.5	15.5	20	22	7.5	20	7.5	15.5	15.5
3	4.5	8	16	8	11.5	16	11.5	8	4.5	4.5	19.5	2	16	16	16	11.5	19.5	21.5	1	11.5	21.5	4.5
4	18.5	1.5	3	11	11	18.5	11	5	11	18.5	11	11	5	1.5	18.5	11	18.5	18.5	18.5	18.5	5	7
5	12	12	3.5	5.5	3.5	12	21.5	19	12	19	19	1.5	1.5	12	12	12	5.5	12	21.5	12	12	12
	55.0	29.0	38	35.5	41.5	51.0	46.5	39.5	38.5	44.5	60.5	19.0	23.5	45.0	62.0	54.5	65.5	59.5	61	49.5	54	39

S = Sum of Squares of observed deviations from the mean of Rj = 3378
K = Number of Sets of rankings = 5
N = Number of individuals ranked = 22
M = Mean = 36
Correction factor = 948

$$W = \frac{S}{\frac{1}{12} K^2 (N^3 - N)}$$

With the correction of Ties $W = \frac{S}{\frac{1}{12} K^2 (N^3 - N) - K\Sigma T}$

$\therefore$ W = .26

$x^2 = 21.8$

Significant at .50 level of Confidence.

TABLE 16

STANDARD SCORES OBTAINED ON SPACE TESTS ONE TO FIVE :- S GROUP I (SUBJECTS 15-36)

SPACE TESTS	SUBJECTS																					
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Space Test 1	- .14	- .4	.26	- .4	.93	.93	1.6	1.6	-1.06	1.6	.93	.93	.93	- .24	.26	-1.06	-1.73	-1.06	-1.06	-3.06	.93	.93
Space Test 2	-2.17	-1.00	-1.88	-1.00	-1.88	-1.00	-1.00	.47	.47	.17	- .41	.17	.17	-1.58	-1.58	-1.29	- .70	-1.00	1.05	- .12	- .41	-1.29
Space Test 3	-.083	-.083	.75	.75	.75	-3.41	.75	.75	.75	-1.75	.75	.75	-1.75	.75	- .91	.91	.75	- .75	-2.58	- .75	- .91	- .91
Space Test 4	.48	- .94	- .37	.48	- .94	-1.22	-1.22	1.62	- .65	1.34	- .65	- .65	- .37	- .37	.77	.48	- .65	.77	- .65	.77	-1.51	-1.51
Space Test 5	- .25	.58	-1.91	-1.08	- .25	- .25	.25	- .58	.25	- .58	-1.91	- .25	- .25	-1.91	-1.08	.58	-1.08	1.41	-1.08	.58	- .25	-1.08

TABLE 17.

KxN TABLE :- RANKINGS OBTAINED BY S GROUP I ON SPACE TESTS

	SUBJECTS																				
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Space Test 1	15	15	11.5	15	7	7	2	2	18.5	2	7	7	7	13	11.5	18.5	21	18.5	18.5	22	7	7
Space Test 2	22	13	20.5	13	20.5	13	13	2.5	2.5	5	8.5	5	5	18.5	18.5	16.5	10	13	1	7	8.5	16.5
Space Test 3	13.5	13.5	6.5	6.5	6.5	22	6.5	6.5	6.5	19.5	6.5	6.5	19.5	6.5	16.5	16.5	6.5	6.5	21	6.5	16.5	16.5
Space Test 4	7	17.5	10	7	17.5	19.5	19.5	1	14	2	14	14	10	10	4	7	14	4	14	4	21.5	21.5
Space Test 5	10.5	3	21	17	10.5	10.5	10.5	4	10.5	4	21	10.5	10.5	21	17	4	17	1	17	4	10.5	17
	68.0	63.0	69.5	63.0	62.0	72.0	51.5	16	52	32.5	57.0	43.0	52.0	69	67.5	62.5	68.5	43	71.5	43.5	64.0	78.5

M = 57.5
S = 4634
Correction factor = 282.5
W = .22

x^2 = 23.1
Significant at .50 level of Confidence

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TABLE 18.

STANDARD SCORES OBTAINED ON TIME TESTS 1, 2, 4 AND 5 :- S GROUP I (SUBJECTS 15-36)

TIME TESTS	SUBJECTS																					
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	.21	.51	1.9	-1.3	.81	-1.3	- .39	-1.3	-.39	- .69	-1.00	- .69	.21	- .39	-1.3	-1.9	- .09	1.12	-1.60	- .09	-1.60	.21
2	- .43	.022	.022	-1.34	.022	.022	1.61	-1.79	- .88	-1.79	.022	.70	.022	-1.79	- .20	-1.56	.022	1.15	-1.56	- .43	1.15	- .43
4	- .70	-1.33	.75	- .29	-1.12	-1.12	- .50	.33	.54	-2.66	- .50	- .91	-1.33	- .70	-1.33	- .91	.75	- .08	- .70	-1.12	- .91	.75
5	- .49	-1.85	.87	-1.85	-1.85	-1.85	- .49	- .49	- .49	- .49	- .49	.87	- .49	- .49	- .49	-1.85	.87	.87	-1.85	-1.85	.87	- .49

TABLE 19

KxN TABLE :- RANKINGS OBTAINED BY S GROUP I ON TIME TESTS

SUBJECTS

TIME TESTS	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	5	3	21.5	16.5	2	16.5	10	16.5	10	12.5	14	12.5	5	10	16.5	21.5	7.5	1	19.5	7.5	19.5	5
2	14	8	8	17	8	8	1	21	16	21	8	4	8	21	12	18.5	8	2.5	18.5	14	2.5	14
4	11	20	2	7	17	17	8.5	5	4	22	8.5	14	20	11	20	14	2	6	11	17	14	2
5	10.5	19	3	19	19	19	10.5	10.5	10.5	10.5	10.5	3	10.5	10.5	10.5	19	3	3	19	19	3	10.5
	40.5	50	34.5	59.5	46	60.5	30.0	53.0	40.5	66.0	41.0	33.5	43.5	52.5	59.0	73.0	20.5	12.5	68.0	57.5	39	31.5

M = 46
S = 5072
Correction factor = 700.0
W = .38

$x^2 = 31.92$

Significant at .10 level of Confidence.

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TABLE 20.

STANDARD SCORES OBTAINED ON NUMBER TESTS TWO TO FIVE :- S GROUP II (SUBJECTS 37-50)

	SUBJECTS													
NUMBER TESTS	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Test 2	- .57	1.00	1.52	- .05	- .57	- .57	- .05	-1.63	.47	.47	.47	- .57	- .05	1.00
Test 3	- .19	.76	- .19	.28	1.23	- .19	1.23	-1.14	- .19	-1.61	.76	- .19	.28	.76
Test 4	- .16	1.91	1.08	- .16	- .58	- 1.0	- .58	.25	.25	- .58	- .58	.16	- .25	-1.00
Test 5	.87	.87	.87	.87	-1.0	.87	.87	-1.0	.87	.87	-1.0	.87	.25	.87

TABLE 21.

KxN TABLE:- RANKINGS OBTAINED BY S GROUP II ON NUMBER TESTS.

	SUBJECTS													
	37	38	39	40	41	42	43	44	45	46	37	48	49	50
NUMBER TESTS														
Test 2	11.5	2.5	1	8	11.5	11.5	8	14	5	5	5	11.5	8	2.5
Test 3	10.0	4	10	6.5	1.5	10	1.5	13	10	14	4	10.0	6.5	4
Test 4	7.0	1	2	7	10.5	13.5	10.5	4	4	10.5	10.5	7.0	4	13.5
Test 5	5.5	5.5	5.5	5.5	13	5.5	5.5	13	5.5	5.5	13	5.5	11	5.5
	34.0	13.0	18.5	27.0	36.5	40.5	25.5	44	24.5	35	32.5	34.0	29.5	25.5

S = 913
M = 30
Correction factor = 466.0
W = .29

x^2 = 15.08
Significant at .50 level Confidence.

TABLE 22.

STANDARD SCORES OBTAINED ON SPACE TESTS 1 TO 5:- S GROUP II

(SUBJECTS 37-50)

SPACE TESTS	SUBJECTS													
	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	-1.06	-1.06	- .4	- .4	.93	-1.06	.93	-1.06	- .4	.26	- .26	- .4	.26	.26
2	.76	.47	.76	- .12	1.64	1.05	1.05	-1.58	.76	-1.58	-1.29	-1.00	- .12	1.05
3	.75	-.083	.75	.75	.75	- .91	.75	- .91	.75	- .91	- .91	-.083	- .91	.75
4	.20	1.05	1.34	- .94	- .65	.20	- .37	-1.8	- .37	.77	- .65	-1.51	.48	1.34
5	1.41	1.41	.58	1.41	.58	- .25	.58	.58	-1.08	- .25	.58	-1.91	- .25	.58

TABLE 23.

KxN TABLE:- RANKINGS OBTAINED BY S GROUP II ON SPACE TESTS.

	SUBJECTS													
SPACE TESTS	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	12.5	12.5	8.5	8.5	1.5	12.5	1.5	12.5	8.5	4.5	4.5	8.5	4.5	4.5
2	6	8	6	9.5	1	3	3	13.5	6	13.5	12	11	9.5	3
3	4	8.5	4	4	4	12	4	12	4	12	12	8.5	12	4
4	6.5	3	1.5	12	10.5	6.5	8.5	14	8.5	4	10.5	13	5	1.5
5	2	2	6.5	2	6.5	11	6.5	6.5	13	11	6.5	14	11	6.5
	31.0	34.0	26.5	36.0	23.5	45	23.5	58.5	40.0	45.0	45.5	55.0	42.0	19.5

Mean = 37.5
S = 1844
Correction factor = 412.5
W = .36

x^2 = 22.75

Significant at .05 level of Confidence.

TABLE 24

STANDARD SCORES OBTAINED ON TIME TESTS 1, 2, 4 AND 5 : S GROUP II - (SUBJECTS 37 - 50)

TIME TESTS	SUBJECTS													
	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Test 1	- .09	1.72	1.42	-1.9	- .09	1.12	.21	- .09	.51	-1.9	-1.00	.81	1.12	.51
Test 2	1.38	1.61	.70	.022	- .88	-1.11	.25	.25	.93	- .20	-1.34	.47	- .43	1.38
Test 4	1.58	.12	1.58	-1.12	.95	.54	.75	- .29	1.33	-2.16	.12	.54	1.37	.12
Test 5	.87	.87	.87	.87	.87	- .49	- .49	- .49	-1.85	- .49	- .49	- .49	.87	- .49

TABLE 25.

KxN TABLE:- RANKINGS OBTAINED BY S GROUP II ON TIME TESTS

TIME TEST	SUBJECTS													
	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	10	1	2	13.5	10	3.5	8	10	7	13.5	12	5.5	3.5	5.5
2	2.5	1	5	9	12	13	7.5	7.5	4	10	14	6	11	2.5
4	1.5	10	1.5	13	5	7.5	6	12	4	14	10	7.5	3	10
5	3.5	3.5	3.5	3.5	3.5	10	10	10	14	10	10	10	3.5	10
	17.5	15.5	12	39.0	30.5	34.0	31.5	39.5	29	47.5	46	29.0	21.0	28.0

M = 30
S = 1519.5
Correction factor - 212
W = .44

x^2 = 22.88
Significant at .05 level of Confidence.

TABLE 26

STANDARD SCORES OBTAINED ON NUMBER TESTS TWO TO FIVE : GROUP III SUBJECTS 1-14

NUMBER SUBTESTS	SUBJECTS 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Subtest 2	1.52	.47	- .05	- .57	1.00	.47	.47	- .57	- .05	-1.63	1.00	1.52	.47	- .05
Subtest 3	- .66	-1.14	-1.14	.76	- .19	.28	.76	- .66	- .19	.28	.76	.28	1.71	.76
Subtest 4	1.91	- .58	-1.00	-1.00	-1.41	-1.00	- .16	- .16	.25	-1.00	- .16	.25	-1.00	- .16
Subtest 5	.87	.87	-1.0	.87	.87	.25	.87	.25	.25	-1.0	.25	.87	-1.0	.87

TABLE 27

KxN TABLE :- RANKINGS FOR S GROUP III ON NUMBER TESTS

SUBJECTS

NUMBER SUBTESTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Subtest 2	1.5	6.5	10	12.5	3.5	6.5	6.5	12.5	10	14	3.5	1.5	6.5	10
Subtest 3	11.5	13.5	13.5	3.5	9.5	7	3.5	11.5	9.5	7	3.5	7	1	3.5
Subtest 4	1	8	11.0	11.0	14	11.0	5.5	5.5	2.5	11.0	5.5	2.5	11.0	5.5
Subtest 5	4	4	13	4	4	9.5	4	9.5	9.5	13.0	9.5	4	13	4
RJ	18.00	32.0	47.5	31.0	31.0	34.0	19.5	39.0	31.5	45.0	22.0	15.0	31.5	23.0

S = 1231.0
K = 4
W = 14
Correction factor = 270

W = 37
x^2 = 19.24
Significant at .10 level of confidence.

TABLE 28

STANDARD SCORES OBTAINED ON SPACE TESTS ONE TO FIVE :- GROUP III (SUBJECTS 1-14)

	SUBJECTS													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SPATIAL TESTS														
Space Test 1	.93	- .4	.26	.26	.26	-1.06	- .4	.26	-1.06	.26	- .4	- .4	.26	-1.73
Space Test 2	.47	.76	1.05	.76	.47	.76	.76	1.05	.76	- .12	- .12	1.05	.17	- .41
	- .91	-.083	-1.75	.75	.75	.75	.75	.75	.75	.75	-.083	.75	.75	-.083
Space Test 4	1.34	-1.51	.48	- .65	1.62	1.34	-1.51	.20	.77	- .65	- .65	- .37	- .08	- .94
Space Test 5	1.41	1.41	- .25	-1.08	-1.91	.58	-1.08	-1.08	.58	1.41	.58	.58	.58	-1.91

TABLE 29

KxN TABLE RANKINGS FOR S GROUP 3 ON SPACE TESTS

	SUBJECTS													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SPATIAL TESTS														
Space Test 1	1	9.5	4.5	4.5	4.5	12.5	9.5	4.5	12.5	4.5	9.5	9.5	4.5	14
Space Test 2	9.5	6	2	6	9.5	6	6	2	6	12.5	12.5	2	11	14
Space Test 4	2.5	13.5	5	10	1	2.5	13.5	6	4	10	10	8	7	12
	13	11	14	5	5	5	5	5	5	5	11	5	5	11
Space Test 5	2	2	9	11	13.5	6	11	11	6	2	6	6	6	13.5
	28.0	42.0	20.5	36.5	33.5	32.0	45.0	28.5	33.5	34.0	49.0	30.5	33.5	64.5
	Total 420													

M = 30
S = 1524.5
Correction factor = 577.5
W = .30

x^2 = 19.5
Significant .20 level of Confidence.

TABLE 30.

STANDARD SCORES OBTAINED ON TIME TESTS 2, 3, 4 and 5 :- S GROUP III (SUBJECTS 1-14)

TIME TESTS	SUBJECTS. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time Test 1	1.12	.51	.21	1.12	.51	-1.3	- .09	- .69	1.12	- .09	.81	.81	- .51	- .09
Time Test 2	1.15	1.15	.022	1.61	.47	- .88	.022	. .47	.93	-1.79	- .65	1.15	.25	.47
Time Test 4	1.37	.12	.33	.33	1.37	.95	- .08	1.37	1.16	- .50	.75	-1.33	- .50	- .29
Time Test 5	- .49	.87	.87	.87	.87	.87	.87	.87	.87	-1.85	.87	.87	.87	.87

TABLE 31.

KxN TABLE;- RANKINGS FOR S GROUP III ON TIME TESTS.

	SUBJECTS													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
TIME TESTS														
Test 1	2	7	9	2	7	14	11	13	2	11	4.5	4.5	7	11
Test 2	3	3	10.5	1	7	13	10.5	7	5	14	12	3	9	7
Test 4	2	9	7.5	7.5	2	5	10	2	4	12.5	6	14	12.5	11
Test 5	13	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	14	6.5	6.5	6.5	6.5
Total of Ranks	20	25.5	33.5	17.0	22.5	38.5	38.0	28.5	17.5	51.5	29.0	28.0	35.0	35.5

M = 30
S = 1175.0
Correction score = 622
W = .39

$x^2 = 20.28$

Significant at .10 level of Confidence.

TABLE 32.

STANDARD SCORES OBTAINED ON NUMBER TESTS: S GROUP IV (SUBJECTS 51-58)

NUMBER TESTS	SUBJECTS 51	52	53	54	55	56	57	58
2	1.52	1.52	1.52	- .57	1.52	1.52	- .05	1.00
3	1.71	.76	1.23	.28	1.71	1.71	1.71	- .19
4	1.91	1.91	1.91	1.5	.25	1.91	.25	1.91
5	.87	.87	.87	.87	.87	.87	.87	.87

KxN TABLE: SCORES OBTAINED BY S GROUP IV ON NUMBER TESTS.

	SUBJECTS 51	52	53	54	55	56	57	58
	3	3	3	8	3	3	7	6
	2.5	6	5	7	2.5	2.5	2.5	8
	3	3	3	6	7.5	3	7.5	3
	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	13.0	16.5	15.5	25.5	17.5	13.0	21.5	21.5

M = 18
S = 139.5
Correction factor = 270
W = .35

$x^2 = 9.80$
Significant at .20 level of Confidence.

TABLE 33.

STANDARD SCORES OBTAINED ON SPACE TESTS: S GROUP IV
(SUBJECTS 51-58)

SPACE TESTS	SUBJECTS 51	52	53	54	55	56	57	58
1	1.6	1.6	1.6	- .4	.26	.9	- .4	.26
2	.76	.76	1.05	.76	.76	.76	1.35	1.05
3	.75	-.083	.75	- .91	.75	.75	- .91	-.083
4	1.62	.77	.77	- .94	1.34	1.62	1.05	.77
5	1.41	.58	.58	- .25	- .25	1.41	- .25	.58

KxN TABLE: RANKINGS OBTAINED BY S GROUP IV ON SPACE TESTS

	SUBJECTS. 51	52	53	54	55	56	57	58
	2	2	2	7.5	5.5	4	7.5	5.5
	6	6	2.5	6	6	6	1	2.5
	2.5	5.5	2.5	7.5	2.5	2.5	7.5	5.5
	1.5	6	6	8	3	1.5	4	6
	1.5	4	4	7	7	1.5	7	4
	13.5	23.5	17.0	38.0	24.0	15.5	27.0	23.5

M = 22.75
S = 424.54
Correction factor = 132.5
W = .46

x^2 = 16.1
Significant at .02 level of Confidence.

TABLE 34.

STANDARD SCORES OBTAINED ON TIME TESTS:- S GROUP IV
(SUBJECTS 51-58)

TIME TESTS	SUBJECTS 51	52	53	54	55	56	57	58
1	1.12	1.42	1.12	1.12	- .69	1.42	- .09	.81
2	.47	.25	1.61	-1.56	.47	- .43	-1.56	.47
4	.95	-1.12	1.16	- .29	.12	1.79	.75	1.37
5	.87	- .49	.87	.87	.87	.87	.87	.87

KxN TABLE:- RANKINGS OBTAINED ON TIME TESTS BY S GROUP IV

	SUBJECTS 51	52	53	54	55	56	57	58
	15	22.5	12	22.5	21	12.5	23.5	15

M = 18
S = 164.0
Correction factor = 132
W =.303

x^2 = 8.48
Significant at = .30 level of Confidence.

TABLE 35.

STANDARD SCORES OBTAINED ON NUMBER TESTS BY

GROUP A_1 (6 yrs. - 6 yrs. 6 mnths.)

TESTS	SUBJECTS								
	E.D.	H.B.	R.M.	A.T.	A.C.	S.B.	P.D.	C.B.	E.F.
2	-1.10	1.00	-.57	.47	-1.10	-1.63	-2.15	- .05	-1.63
3	-1.14	- .66	.28	.76	-1.14	1.71	-1.61	-2.09	- .66
4	1.5	- .58	- .58	- .58	-1.00	-1.00	-1.00	-1.00	- .58
5	.25	-2.25	-1.0	.87	-1.00	-2.25	- .37	-1.00	-1.0

STANDARD SCORES OBTAINED ON NUMBER TESTS BY

GROUP A_2 (6 yrs. 7 mnths. - 7 yrs.)

TESTS	SUBJECTS									
	M.B.	S.M.	N.A.	P.A.	J.M.	I.F.	M.G.	H.S.	K.S.	A.G.
2	-1.63	- .57	- .05	-1.10	.47	1.00	- .57	-1.10	-1.10	1.52
3	.28	- .19	- .66	- .66	-1.14	.28	-1.61	-1.14	-2.09	-1.14
4	-1.00	- .58	-1.00	- .58	-1.00	-1.0	- .58	1.91	.25	.25
5	-1.00	- .37	-1.00	.25	-1.00	-1.62	-1.0	-1.0	-1.0	.87

TABLE 36.

STANDARD SCORES OBTAINED ON SPACE TESTS BY

GROUP A_1 (6 yrs. - 6 yrs. 6 mnths.)

TESTS	SUBJECTS								
	E.D.	H.B.	R.M.	A.T.	A.C.	S.B.	P.D.	C.B.	E.F.
1	.26	1.6	-1.06	.93	.26	-1.06	-1.73	-1.06	-1.06
2	-1.88	-1.00	.47	.17	-1.58	1.05	- .70	-1.00	-1.26
3	.75	.75	.75	.75	- .91	-2.58	.75	.75	- .91
4	- .37	-1.22	- .65	- .65	.77	- .65	- .65	.77	.48
5	-1.91	- .25	- .25	- .25	-1.08	-1.08	-1.08	1.41	.58

STANDARD SCORES OBTAINED ON SPACE TESTS BY

GROUP A_2 (6 yrs. 7 mnths. - 8 yrs.)

TESTS	SUBJECTS									
	M.B.	S.M.	N.A.	P.A.	J.M.	I.F.	M.G.	H.S.	K.S.	A.G.
1	- .4	- .4	-3.06	.93	.93	1.6	.93	-2.4	.93	.93
2	-2.17	-1.00	- .12	-1.88	-1.00	.17	- .41	-1.58	- .41	.17
3	-.083	.75	.75	.75	-3.41	-1.75	.75	.75	- .91	-1.75
4	.48	.48	.77	- .94	-1.22	1.34	- .65	- .37	-1.51	- .37
5	- .25	-1.08	.58	- .25	- .25	.58	-1.91	-1.91	- .25	- .25

TABLE 37.

STANDARD SCORES OBTAINED ON TIME TESTS FOR

GROUP A_1 (6 yrs. - 6 yrs. 6 mnths.)

TESTS	SUBJECTS								
	E.D.	H.B.	R.M.	A.T.	A.C.	S.B.	P.D.	C.B.	E.F.
1	-1.9	- .39	- .39	- .69	-1.3	-1.60	- .09	1.12	-1.9
2	.022	1.61	- .88	.70	- .20	-1.56	.022	1.15	-1.56
4	.75	-.50	.54	- .91	-1.33	- .70	.75	- .08	- .91
5	.87	- .49	- .49	.87	- .49	-1.85	.87	.87	-1.85

STANDARD SCORES OBTAINED ON TIME TESTS BY

GROUP A_2 (6 yrs. 7 mnths. - 7 yrs.)

TESTS	SUBJECTS									
	M.B.	S.M.	N.A.	P.A.	J.M.	I.F.	M.G.	H.S.	K.S.	A.G.
1	.21	-1.3	- .09	.81	-1.3	- .69	-1.00	- .39	-1.60	.21
2	- .43	-1.34	- .43	.022	.022	-1.79	.022	-1.79	1.15	.022
4	- .70	- .29	-1.12	-1.12	-1.12	-2.66	- .50	- .70	- .91	-1.33
5	- .49	-1.85	-1.85	-1.85	-1.85	- .49	- .49	- .49	.87	- .49

TABLE 38.

STANDARD SCORES OBTAINED ON NUMBER TESTS BY

GROUP B_1 (7 yrs. - 7 yrs. 6 mnths.)

TESTS	SUBJECTS						
	C.H.	B.J.	G.Q.	M.W.	M.G.	R.S.	B.G.
2	- .05	.47	- .05	-1.10	- .57	- .57	- .05
3	- .19	-1.61	- .19	.28	- .19	- .19	.28
4	1.91	- .58	.25	- .16	- .16	- .16	- .16
5	-1.0	.87	-1.62	-1.0	.87	.87	.87

STANDARD SCORES OBTAINED ON NUMBER TESTS BY

GROUP B_2 (7 yrs. 7 mnths. - 8 yrs.)

TESTS	SUBJECTS								
	L.S.	A.S.	J.S.	P.G.	K.R.	S.G.	F.T.	W.H.	M.T.
2	.47	.47	.47	1.00	1.52	- .57	- .57	- .05	1.00
3	.76	- .19	.76	.76	- .19	1.23	- .19	1.23	.76
4	- .58	.25	- .16	-1.00	1.08	- .58	-1.0	- .58	1.91
5	-1.0	.87	.87	.87	.87	-1.0	.87	.87	.87

TABLE 39.

STANDARD SCORES OBTAINED ON SPACE TESTS BY

GROUP B_1 (7 yrs. - 7 yrs. 6 mnths.)

TESTS	SUBJECTS						
	C.H.	B.J.	G.Q.	M.W.	M.G.	R.S.	B.G.
1	- .4	.26	1.6	.93	- .4	-1.06	- .4
2	-1.00	-1.58	.47	-1.29	-1.00	.76	- .12
3	-.083	- .91	.75	- .91	-.083	.75	.75
4	- .94	.77	1.62	-1.51	-1.51	.20	- .94
5	.58	- .25	.58	-1.08	-1.91	1.41	1.41

STANDARD SCORES OBTAINED ON SPACE TESTS BY

GROUP B_2 (7 yrs. 7 mnths. - 8 yrs.)

TESTS	SUBJECTS								
	L.S.	A.S.	J.S.	P.G.	K.R.	S.G.	F.T.	W.H.	M.T.
1	.26	- .4	- .4	.26	- .4	.93	-1.06	.93	-1.06
2	-1.29	.76	.76	1.05	.76	1.64	1.05	1.05	.47
3	- .91	.75	.75	.75	.75	.75	- .91	.75	-.083
4	- .65	- .37	-1.51	1.34	1.34	- .65	.20	- .37	1.00
5	.58	-1.08	-1.08	.58	.58	.58	- .25	.58	1.41

TABLE 40.

STANDARD SCORES OBTAINED ON TIME TESTS BY

GROUP B_1 (7 yrs. - 7 yrs. 6 mnths.)

TESTS	SUBJECTS.						
	C.H.	B.J.	G.Q.	M.W.	M.G.	R.S.	B.G.
1	.51	-1.9	-1.3	.21	.81	- .09	-1.9
2	.022	- .20	-1.79	- .43	.47	1.38	.022
4	-1.33	-2.16	.33	.75	.54	1.58	-1.12
5	-1.85	- .49	- .49	- .49	- .49	.87	.87

STANDARD SCORES OBTAINED ON TIME TESTS BY

GROUP B_2 (7 yrs. 6 mnths. - 8 yrs.)

TESTS	SUBJECTS								
	L.S.	A.S.	J.S.	P.G.	K.R.	S.G.	F.T.	W.H.	M.T.
1	-1.00	.51	- .L9	.81	1.42	- .09	1.12	.21	1.72
2	-1.34	.93	.022	1.38	.70	- .88	-1.11	.25	1.61
4	.12	1.33	- .08	.12	1.58	.95	.54	.75	.12
5	- .49	-1.85	.87	- .49	.87	.87	- .49	- .49	.87

TABLE 41.

STANDARD SCORES OBTAINED ON NUMBER TESTS BY

GROUP C_1 (8 yrs. - 8 yrs. 6 mnths.)

TESTS	SUBJECTS								
	M.W.	S.P.	D.A.	P.C.	D.H.	M.L.	K.vd.M.	G.S.	C.D.
2	1.52	-1.63	- .05	- .57	1.00	- .05	- .05	- .05	.47
3	- .66	-1.14	-1.14	.76	- .19	.76	- .19	.28	.28
4	1.91	.25	-1.00	-1.00	-1.41	- .16	.25	.25	-1.00
5	.87	-1.0	-1.00	.87	.87	.87	.25	.25	.25

STANDARD SCORES OBTAINED ON NUMBER TESTS BY

GROUP C_2 (8 yrs. 7 mnths. - 9 yrs.)

TESTS	SUBJECTS					
	A.B.	G.G.	G.McF.	J.v.A.	E.S.	L.M.
2	.47	1.52	- .57	-1.63	1.00	.47
3	-1.14	.28	- .66	.28	.76	1.71
4	- .58	.25	- .16	-1.00	- .16	-1.00
5	.87	.87	.25	-1.00	.25	-1.00

TABLE 42.

STANDARD SCORES OBTAINED ON SPACE TESTS BY

GROUP C_1 (8 yrs. - 8 yrs. 6 mnths.)

TESTS	SUBJECTS								
	M.W.	S.P.	D.A.	P.C.	D.H.	M.L.	K.vd.M.	G.S.	C.D.
1	.93	-1.06	.26	.26	.26	-1.73	-1.06	.26	-1.06
2	.47	-1.58	1.05	.76	.47	- .41	.76	- .12	.76
3	- .91	- .91	-1.75	.75	.75	-.083	.75	- .91	.75
4	1.34	-1.8	.48	- .65	1.62	- .94	.77	.48	1.34
5	1.41	.58	- .25	-1.08	-1.91	-1.91	.58	- .25	.58

STANDARD SCORES OBTAINED ON SPACE TESTS BY

GROUP C_2 (8 yrs. 7 mnths. - 9 yrs.)

TESTS	SUBJECTS					
	A.B.	G.G.	G.McF.	J.v.A.	E.S.	L.M.
1	- .4	- .4	.26	.26	- .4	.26
2	.76	1.05	1.05	- .12	- .12	.17
3	-.073	.75	.75	.75	-.083	.75
4	-1.51	- .37	.20	- .65	- .65	- .08
5	1.41	.58	-1.08	1.41	.58	.58

TABLE 43.

STANDARD SCORES OBTAINED ON TIME TESTS BY

GROUP C_1 (8 yrs. - 8 yrs. 6 mnths.)

TESTS	SUBJECTS								
	M.W.	S.P.	D.A.	P.C.	D.H.	M.L.	K.v.M.	G.S.	C.D.
1	1.12	- .09	.21	1.12	.51	- .09	1.12	1.12	-1.3
2	1.15	.25	.022	1.61	.47	.47	.93	- .43	- .88
4	1.37	- .29	.33	.33	1.37	- ,29	1.16	1.37	.95
5	- .49	- .49	.87	.87	.87	.87	.87	.87	.87

STANDARD SCORES OBTAINED ON TIME TESTS BY

GROUP C_2 (8 yrs. 7 mnths. - 9 yrs.)

TESTS	SUBJECTS					
	A.B.	G.G.	G.McF.	J.v.A.	E.S.	L.M.
1	.51	.81	- .69	- .09	.81	.51
2	1.15	1.15	.47	-1.79	- .65	.25
4	.12	-1.33	1.37	- .50	.75	- .50
5	.87	.87	.87	-1,85	.87	.87

TABLE 44.

KxN TABLE :- RANKINGS FOR GROUP A_1 (6.0 - 6.6 yrs.) ON NUMBER TESTS.

NO. TESTS	SUBJECTS								
	E.D.	H.B.	R.M.	A.T.	A.C.	S.B.	P.D.	C.B.	E.F.
1	5.5	1	4	2	5.5	7.5	9	3	7.5
2	6.5	4.5	3	2	6.5	1	8	9	4.5
3	1	3.5	3.5	3.5	7.5	7.5	7.5	7.5	3.5
4	2	8.5	5.5	1	5.5	8.5	3	5.5	5.5
Sum of Ranks	15.0	17.5	16.0	8.5	25.0	24.5	27.5	25.0	21.0

M = 20.0
S = 307.00
Correction factor = 70
W = .34

x^2 = 10.88
Significant at .30 level of Confidence.

KxN TABLE :- RANKINGS FOR GROUP A_2 (6.7 - 7 yrs.) ON NUMBER TESTS

TESTS	SUBJECTS									
	M.B.	S.M.	N.A.	P.A.	J.M.	I.F	M.G.	H.S.	K.S.	A.G.
1	10	5.5	4	8	3	2	5.5	8	8	1
2	1.5	3	4.5	4.5	7	1.5	9	7	10	7
3	8.5	5	8.5	5	8.5	8.5	5	1	2.5	2.5
4	6.5	3	6.5	2	6.5	10	6.5	6.5	6.5	1
Sum of Ranks	26.5	16.5	23.5	19.5	25.0	22.0	26.0	22.5	27.0	11.5

M = 22
S = 219.50
Correction factor = 122.0
W = .18

x^2 = 6.48
Significant at .70 level of Confidence.

TABLE 45.

KxN TABLE:- RANKINGS FOR GROUP A_1 (6.0 - 6.6 yrs.) ON SPACE TESTS

TESTS	SUBJECTS								
	E.D.	H.B.	R.M.	A.T.	A.C.	S.B.	P.D.	C.B.	E.F.
1	3.5	1	6.5	2	3.5	6.5	9	6.5	6.5
2	9	5.5	2	3	8	1	4	5.5	7
3	3.5	3.5	3.5	3.5	7.5	9	3.5	3.5	7.5
4	4	9.0	6.5	6.5	1.5	6.5	6.5	1.5	3
5	9	4	4	4	7	7	7	1.0	2
Total of Ranks	29.0	23.0	22.5	19.0	27.5	30.0	30.0	18.0	26.0

M = 25
S = 168.5
Correction factor 167.5
W = .13

x^2 = 5.2
Significant at .80 level of Confidence.

KxN TABLE :- RANKINGS FOR GROUP A_2 (6.7 - 7.0 yrs.) ON SPACE TESTS

TESTS	SUBJECTS									
	M.B.	S.M.	N.A.	P.A.	J.M.	I.F.	M.G.	H.S.	K.S.	A.G.
1	7.5	7.5	10	4	4	1	4	9	4	4
2	10	6.5	3	9	6.5	1.5	4.5	8	4.5	1.5
3	6	3	3	3	10	8.5	3	3	7	8.5
4	3.5	3.5	2	8	9	1	7	5.5	10	5.5
5	5	8	1.5	5	5	1.5	9.5	9.5	5	5
Total of Ranks	32.0	28.5	19.5	29	34.5	13.5	28.0	35	30.5	24.5

M = 27.5
S = 407.00
Correction factor 172.5
W = .22

x^2 = 9.90
Significant at .50 level of Confidence.

TABLE 46.

KxN TABLE :- RANKINGS FOR GROUP A_1 (6.0 - 6.6 yrs.) ON TIME TESTS

TESTS	SUBJECTS								
	E.D.	H.B.	R.M.	A.T.	A.C.	S.B.	P.D.	C.B.	E.F.
1	8.5	3.5	3.5	5	6	7	2	1	8.5
2	4.5	1	7	3	6	8.5	4.5	2	8.5
4	1.5	5	3	7.5	9	6	1.5	4	7.5
5	2.5	6	6	2.5	6	8.5	2.5	2.5	8.5
Total Ranks	17.0	15.5	19.5	18.0	27	30.0	10.5	9.5	33.0

M = 20
S = 552.0
Correction factor = 42.0
W = .60

x^2 = 19.2
Significant at .02 level of Confidence.

KxN TABLE:- RANKINGS FOR GROUP A_2 (6.7 - 7.0 yrs.) ON TIME TESTS

TESTS	SUBJECTS.									
	M.B.	S.M.	N.A.	P.A.	J.M.	I.F.	M.G.	H.S.	K.S.	A.G.
1	2.5	8.5	4	1	8.5	6	7	5	10	2.5
2	6.5	8	6.5	3.5	3.5	9.5	3.5	9.5	1	3.5
4	3.5	1	7	7	7	10	2	3.5	5	9
5	4	8.5	8.5	8.5	8.5	4	4	4	1	4
Total Ranks	16.5	26.0	26.0	20.0	27.5	29.5	16.5	22.0	17	19.0

M = 22.0
S = 217.00
Correction factor 98.0
W = .18

x^2 = 6.48
Significant at .70 level of Confidence.

TABLE 47.

KxN TABLE :- RANKINGS FOR GROUP B_1 (7.0 - 7.6 yrs.) ON NUMBER TESTS

TESTS	SUBJECT						
	C.H.	B.J.	G.Q.	M.W.	M.G.	R.S.	B.G.
2	3	1	3	7	5.5	5.5	3
3	4.5	7	4.5	1.5	4.5	4.5	1.5
4	1	7	2	4.5	4.5	4.5	4.5
5	5.5	2.5	7	5.5	2.5	2.5	2.5
Total of Ranks	14.0	17.5	16.5	18.5	17.0	17.0	11.5

M = 16
S = 35.00
Correction factor = 74.0
W = .093

KxN TABLE :- RANKINGS FOR GROUP B_2 (7.7 - 7.11 yrs.) ON NUMBER TESTS

TESTS	SUBJECT								
	L.S	A.S.	J.S.	P.G.	K.R.	S.G.	F.T.	W.H.	M.T.
2	5	5	5	2.5	1	8.5	8.5	7	2.5
3	4.5	8	4.5	4.5	8	1.5	8	1.5	4.5
4	6	3	4	8.5	2	6	8.5	6	1
5	8.5	4	4	4	4	8.5	4	4	4
Total of Ranks	24.0	20.0	17.5	19.5	15.0	24.5	29.0	18.5	12.0

M = 20
S = 215.0
Correction factor = 198.0
W = .27

$x^2 = 8.64$
Significant at .50 level of Confidence.

TABLE 48.

KxN TABLE :- RANKINGS FOR GROUP B_1 (7.0 - 7.6 yrs.) ON SPACE TESTS

TESTS	SUBJECTS						
	C.H.	B.J.	S.Q.	M.W.	M.G.	R.S.	B.G.
1	5	3	1	2	5	7	5
2	4.5	7	2	6	4.5	1	3
3	4.5	6.5	2	6.5	4.5	2	2
4	4.5	2	1	6.5	6.5	3	4.5
5	3.5	5	3.5	6	7	1.5	1.5
Total Ranks	22.0	23.5	9.5	27.0	27.5	14.5	16.0

M = 20
S = 278
Correction factor = 37.5
W = .42

$x^2 = 8.64$
Significant at .05 level of Confidence.

KxN TABLE :- RANKINGS FOR GROUP B_2 (7.7 - 8.0 yrs.) ON SPACE TESTS

TESTS	SUBJECTS								
	L.S.	A.S.	J.S.	P.G.	K.R.	S.G.	F.T.	W.H.	M.T.
1	3.5	6	6	3.5	6	1.5	8.5	1.5	8.5
2	9	6	6	3	6	1	3	3	8
3	8.5	3.5	3.5	3.5	3.5	3.5	8.5	3.5	7
4	7.5	5.5	9	1.5	1.5	7.5	4	5.5	3
5	4	8.5	8.5	4	4	4	7	4	1
Total Ranks	32.5	29.5	33.0	15.5	21.0	17.5	31	17.5	27.5

M = 25
S = 401.5
Correction factor 187.5
W = .305

$x^2 = 12.2$
Significant at .20 level of Confidence.

TABLE 49.

KxN TABLE :- RANKINGS FOR GROUP B_1 (7.0 - 7.6 yrs.) ON TIME TESTS.

TESTS	SUBJECTS						
	C.H.	B.J.	G.Q.	M.W.	M.G.	R.S.	B.G.
1	2	6.5	5	3	1	4	6.5
2	3.5	5	7	6	2	1	3.5
4	6	7	4	2	3	1	5
5	7	4.5	4.5	4.5	4.5	1.5	1.5
Total Ranks	18.5	23.0	20.5	15.5	10.5	7.5	16.5

M = 16
S = 178.5
Correction factor = 23
$W = \frac{178.5}{422}$ $\therefore$ W = .42

KxN TABLE :- RANKINGS FOR GROUP B_2 (7.7 - 8.0 yrs.) ON TIME TESTS

TESTS	SUBJECTS								
	L.S.	R.S.	J.S.	P.G.	K.R.	S.G.	F.T.	W.H.	M.T.
1	9	5	7.5	4	2	7.5	3	6	1
2	9	3	6	2	4	7	8	5	1
4	7	2	9	7	1	3	5	4	7
5	6.5	9	2.5	6.5	2.5	2.5	6.5	6.5	2.5
Total Ranks	31.5	19	25.0	19.5	9.5	20	22.5	21.5	11.5

M = 20
S = 349.5
Correction factor = 50
W = .38

$x^2 = 12.16$
Significant at .20 level of Confidence.

TABLE 50.

KxN TABLE :- RANKINGS FOR GROUP C_1 (8.0 - 8.6 yrs.) ON NUMBER TESTS

TESTS	SUBJECTS								
	M.W.	S.P.	D.A.	P.C.	D.H.	M.L.	K.vd.M.	G.S.	C.D.
2	1	9	5.5	8	2	5.5	5.5	5.5	3
3	7	8.5	8.5	1.5	5.5	1.5	5.5	3.5	3.5
4	1	3	7	7	9	5	3	3	7
5	2.5	8.5	8.5	2.5	2.5	2.5	6	6	6
Total Ranks	11.5	29.0	29.5	19.0	19.0	14.5	20.0	18.0	19.5

M = 20
S = 280
Correction factor = 74.0
W = .32

$x^2 = 10.24$
Significant at .30 level of Confidence.

KxN TABLE :- RANKINGS FOR GROUP C_2 (8.0 yrs. 7 mnths. - 9 yrs.) ON NUMBER TESTS.

TESTS	SUBJECTS					
	A.B.	G.G.	G.McF.	J.v.A.	E.S.	L.M.
2	3.5	1	5	6	2	3.5
3	6	3.5	5	3.5	2	1
4	4	1	2.5	5.5	2.5	5.5
5	1.5	1.5	3.5	5.5	3.5	5.5
Total Ranks	15.0	7.0	16.0	20.5	10.0	15.5

M = 14
S = 114.5
Correction factor = 14.0
W = .43

TABLE 51.

KxN TABLE :- RANKINGS FOR GROUP C_1 (8.0 - 8.6 yrs.) ON SPACE TESTS.

TESTS	SUBJECTS								
	M.U.	S.P.	D.A.	P.C.	D.H.	M.L.	K.vd.M.	G.S.	C.D.
1	1	7	3.5	3.5	3.5	9	7	3.5	7
2	5.5	9	1	3	5.5	8	3	7	3
3	7	7	9	2.5	2.5	5	2.5	7	2.5
4	2.5	9	5.5	7	1	8	4	5.5	2.5
5	1	3	5.5	7	8.5	8.5	3	5.5	3
Total Ranks	17	35	24.5	23.0	21.0	38.5	19.5	28.5	18

M = 25
S = 458
Correction factor = 102.5
W = .33

x^2 = 13.2
Significant at .10 level of Confidence.

KxN TABLE :- RANKINGS FOR GROUP C_2 (8.7 - 9.0 yrs.) ON SPACE TESTS

TESTS	SUBJECTS					
	A.B.	G.G.	G.McF.	J.v.A.	E.S.	L.M.
1	5	5	2	2	5	2
2	3	1.5	1.5	5.5	5.5	4
3	5.5	2.5	2.5	2.5	5.5	2.5
4	6	3	1	4.5	4.5	2
5	1.5	4	6	1.5	4	4
Total Ranks	21.0	16.0	13.0	16.0	24.5	14.5

M = 17.5
S = 95.0
Correction factor = 67.5
W = .25

TABLE 52.

KxN TABLE : RANKINGS FOR GROUP C_1 (8.0 - 8 yrs. 6 mnths.)

ON TIME TESTS.

TESTS	SUBJECTS								
	M.W.	S.P.	D.A.	P.C.	D.H.	M.L.	K.vd.M.	G.S.	C.D.
1	2.5	7.5	6	2.5	5	7.5	2.5	2.5	9
2	2	6	7	1	4.5	4.5	3	8	9
4	2	8.5	6.5	6.5	2	8.5	4	2	5
5	8.5	8.5	4	4	4	4	4	4	4
Total Ranks	15.0	30.5	23.5	14.0	15.5	24.5	13.5	16.5	27

M = 20
S = 327.5
Correction factor = 142.
W = .400

x^2 = 12.8
Significant at .20 level of Confidence.

KxN TABLE :- RANKINGS FOR GROUP C_2 (8.0 yrs. 7 mnths. - 9 yrs.) ON TIME TESTS.

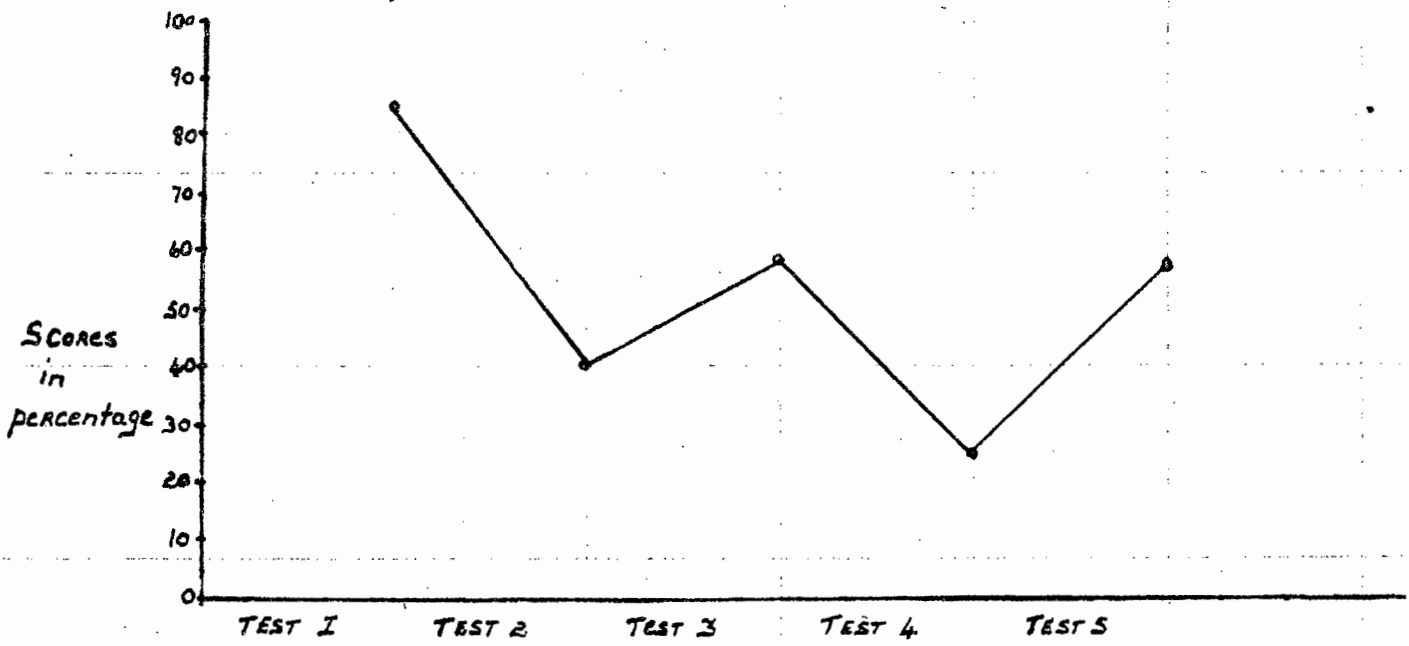
TESTS	SUBJECTS					
	A.B.	G.G.	G.McF.	J.v.A.	E.S.	L.M.
1	3.5	1.5	6	5	1.5	3.5
2	1.5	1.5	3	6	5	4
4	3	6	1	4.5	2	4.5
5	3	3	3	6	3	3
Total Ranks	11.0	12	13	21.5	11.5	15.0

M = 14
S = 77.50
Correction factor = 48.
W = .33

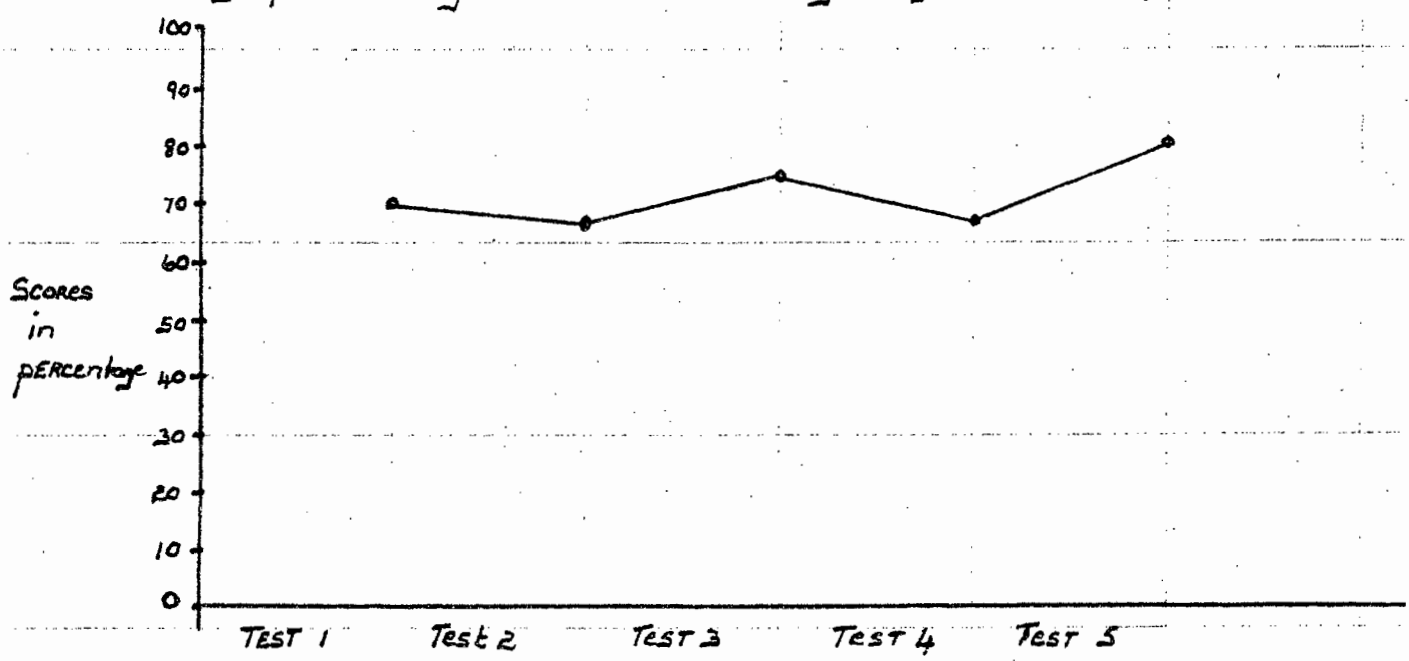
GRAPHS REPRESENTING RESULTS OF FIVE SUBJECTS DRAWN FROM

SUB A. GROUP

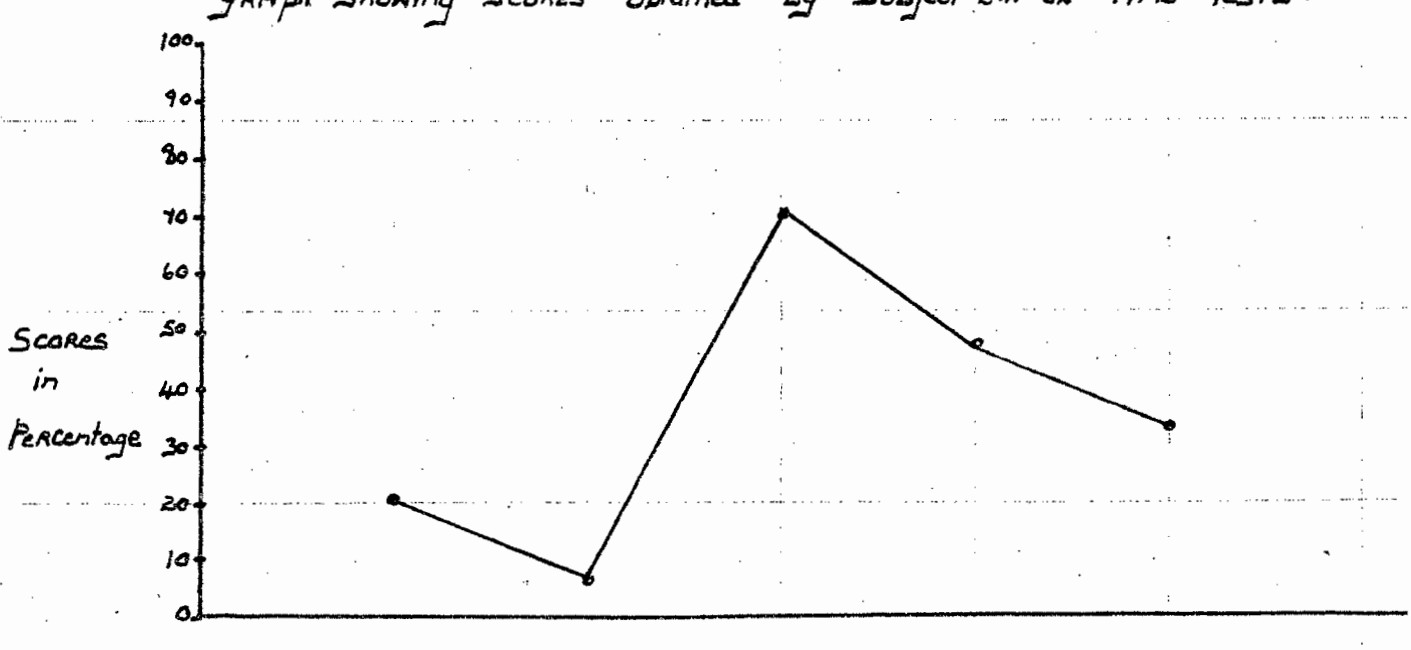
GRAPH showing scores obtained by Subject E.F. ON NUMBER Tests.



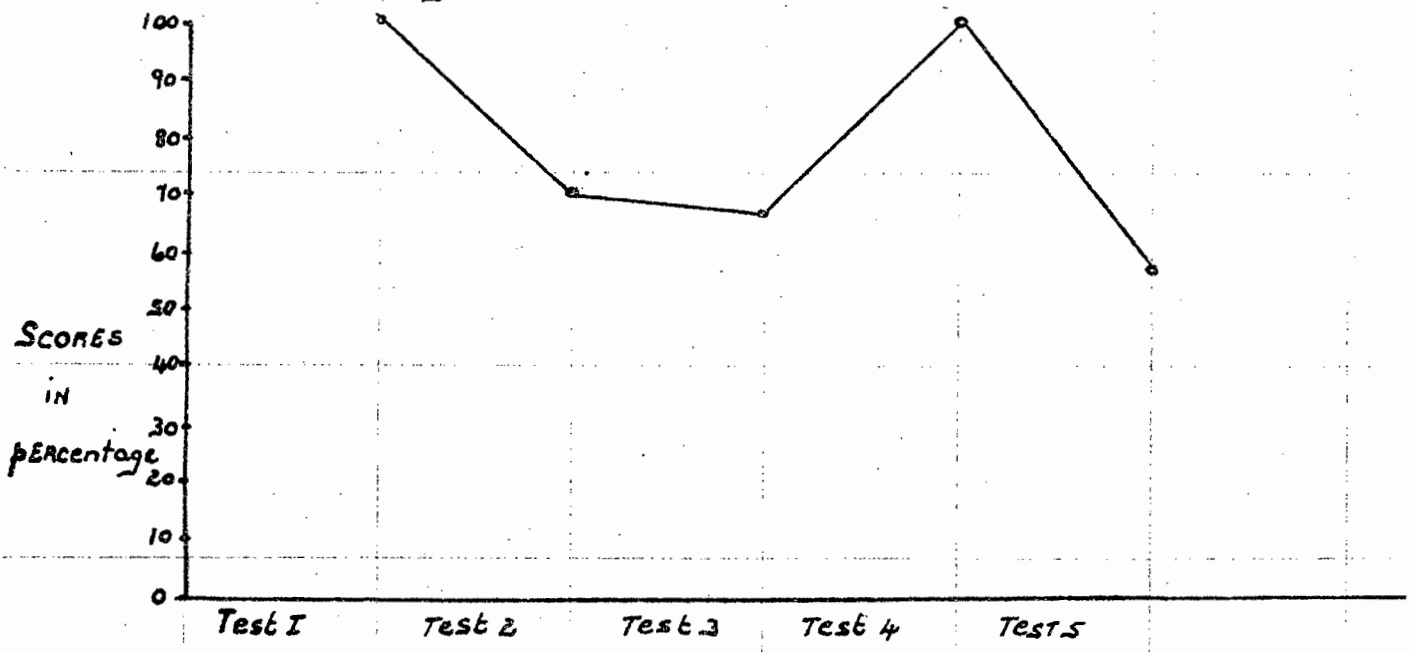
GRAph Showing SCORES obtained by SUBJECT E.F. ON SPACE TESTS.



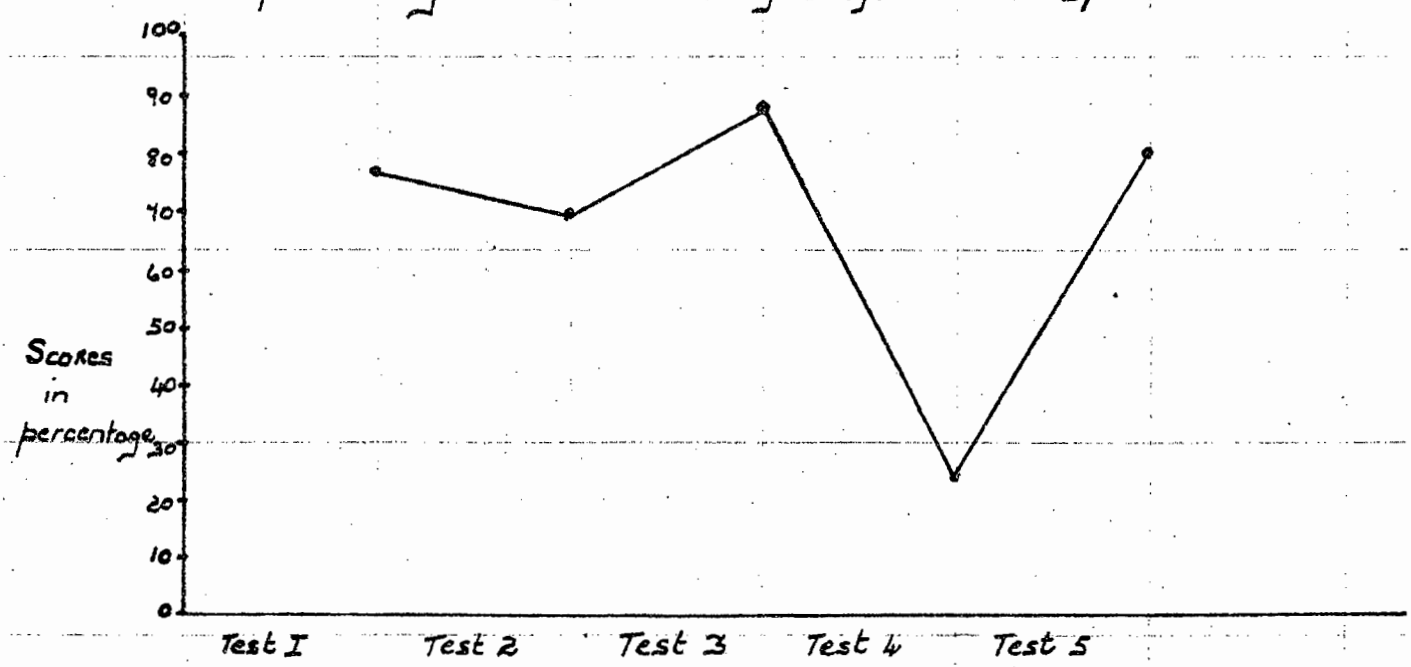
GRAph Showing SCORES obtained by SUBJECT E.F. ON Time TESTS.



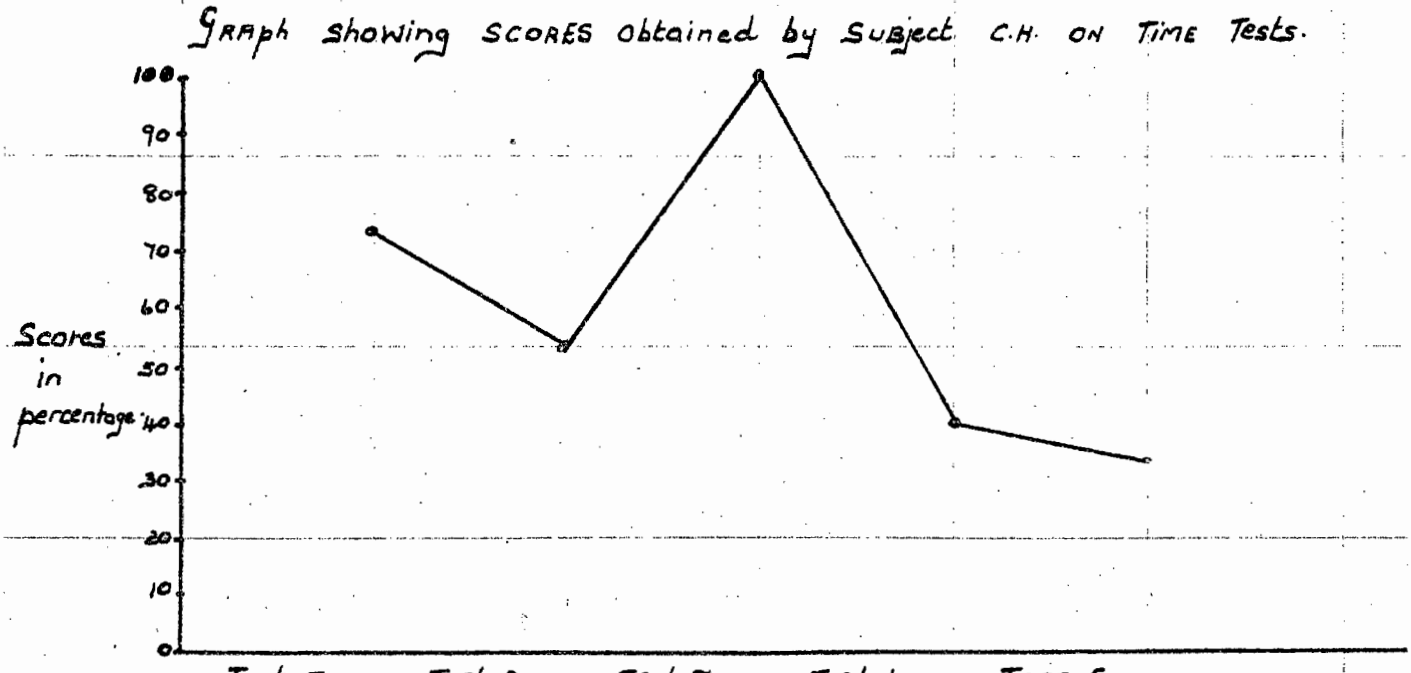
Graph showing Scores obtained by Subject C.H. on Number Tests.



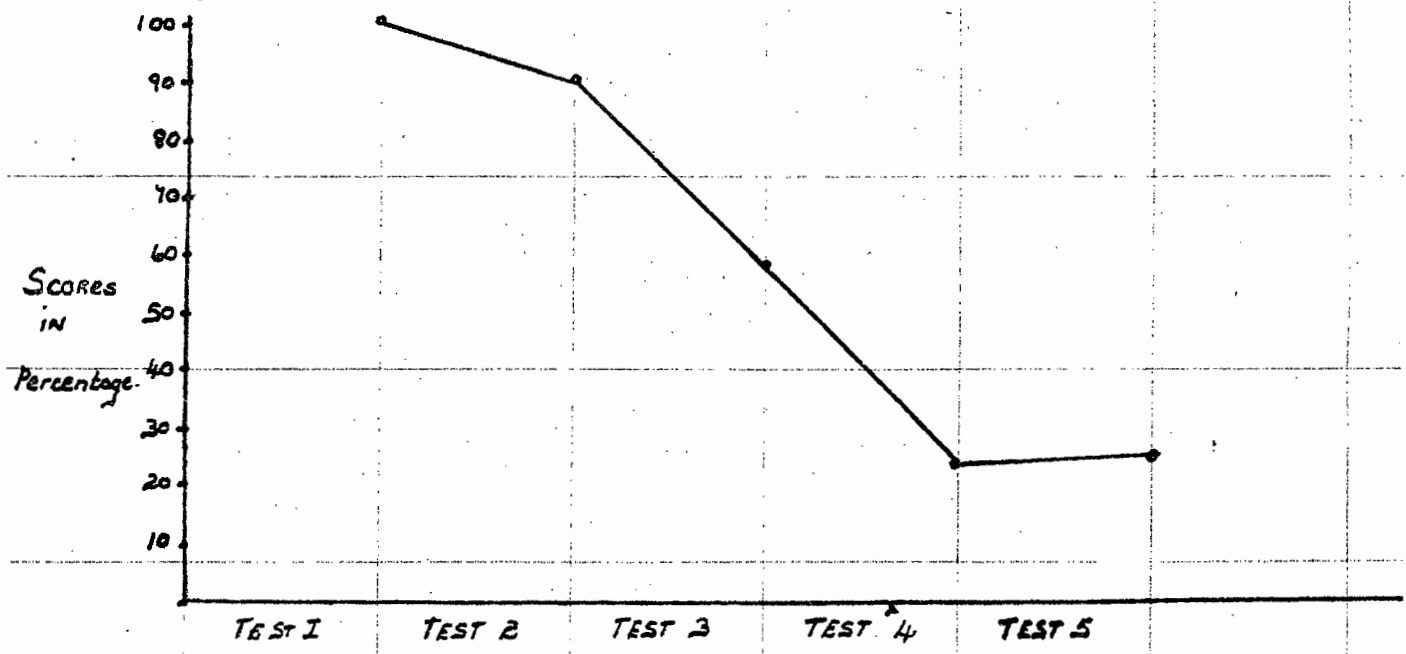
Graph showing Scores obtained by Subject C.H. on Space Tests.



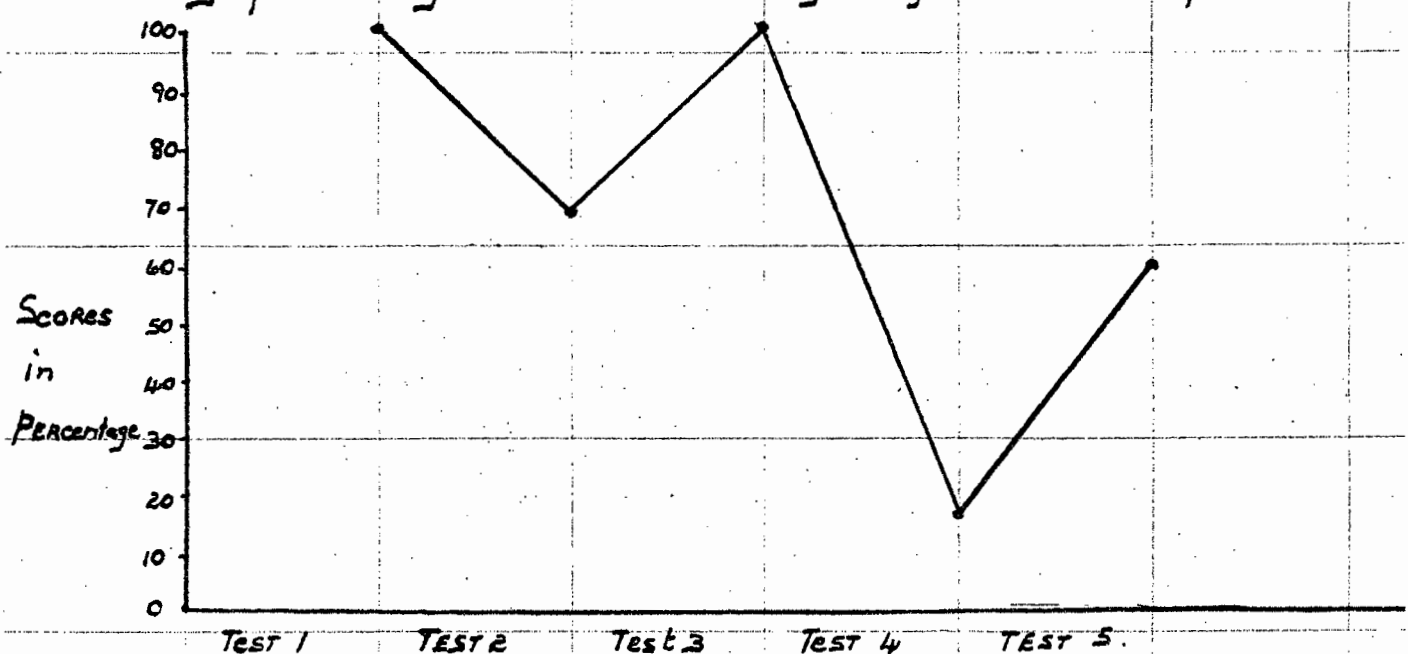
Graph showing Scores obtained by Subject C.H. on Time Tests.



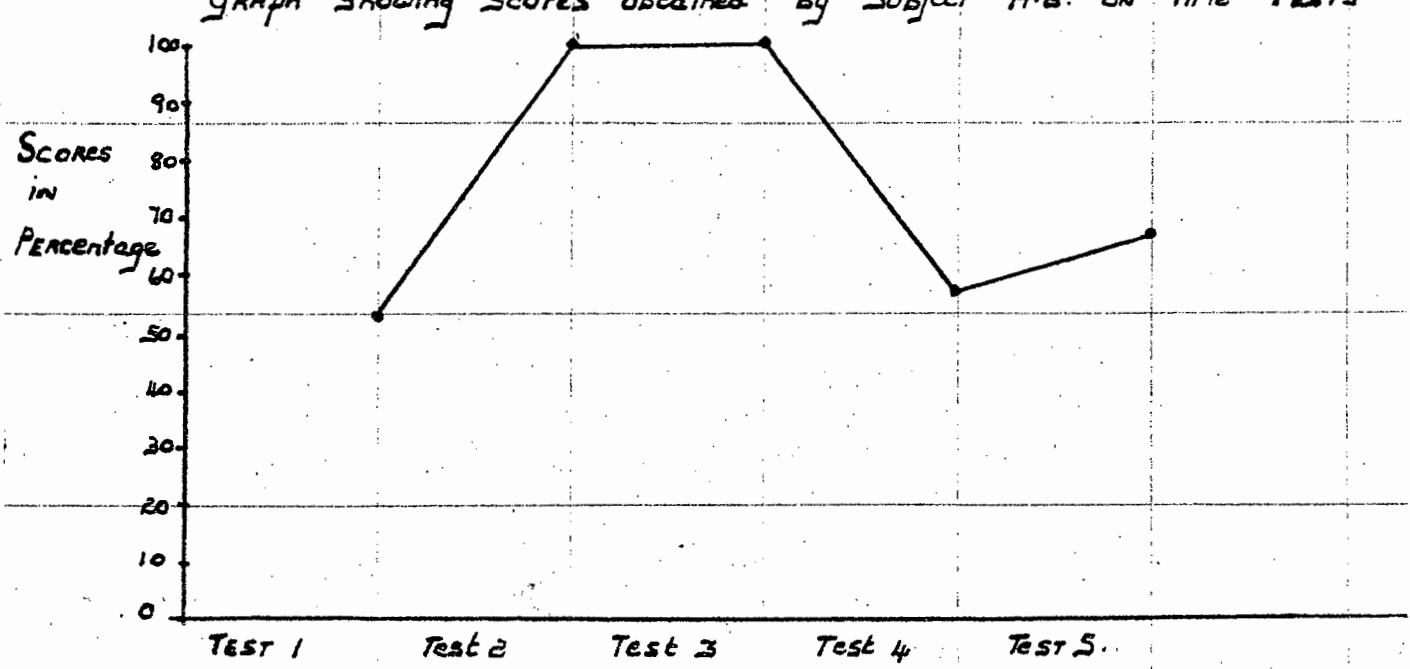
Graph Showing Scores obtained on Number Tests By Subjects H.B.



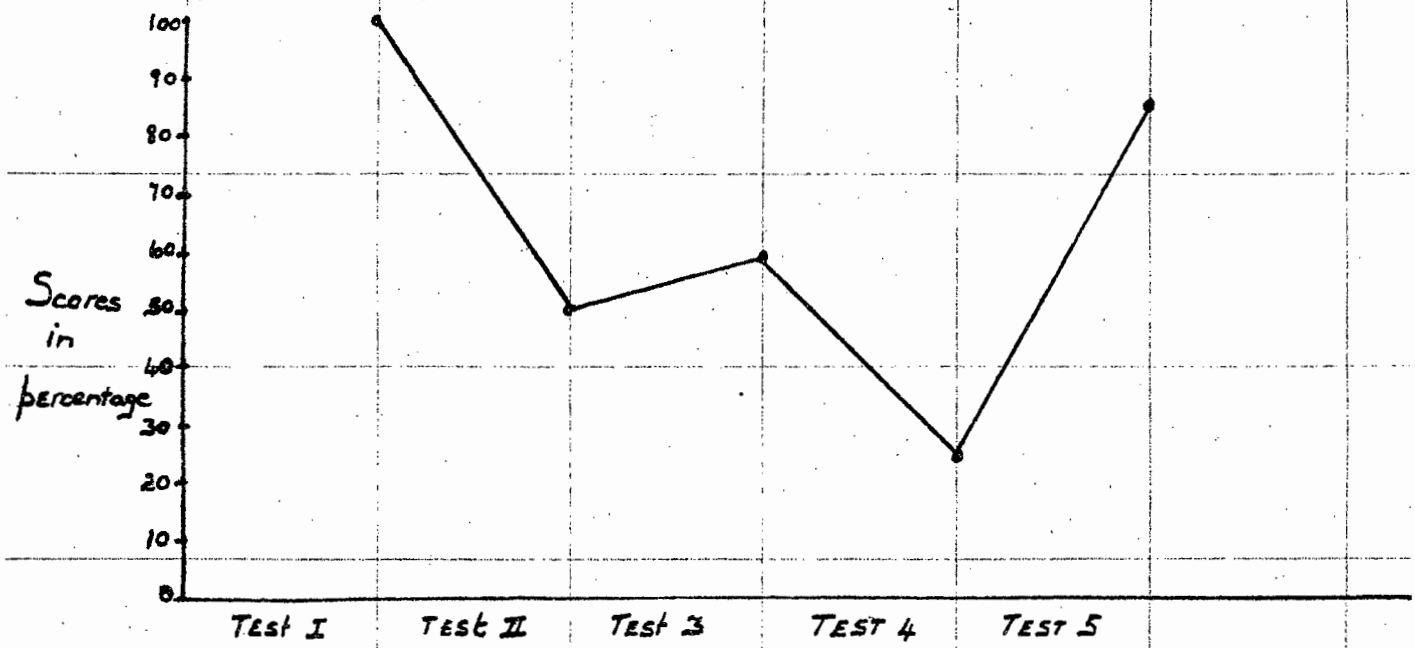
Graph showing Scores obtained by Subject H.B. on Space Tests



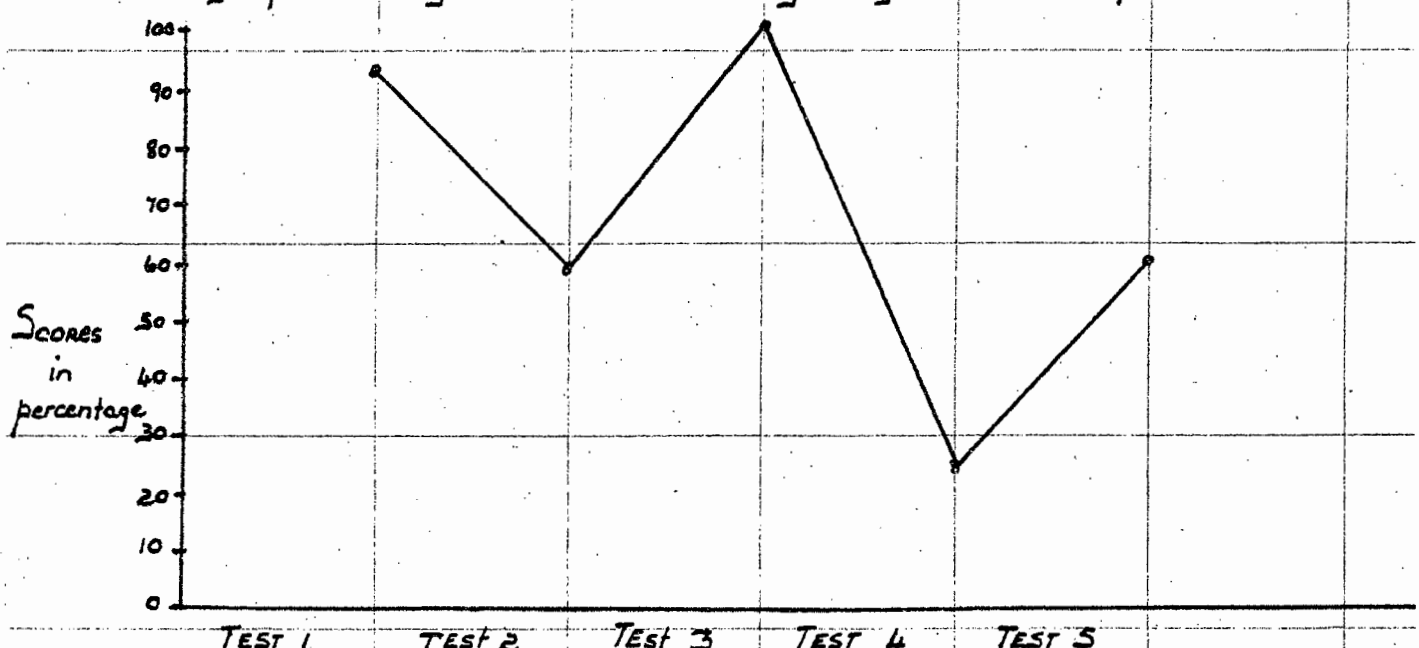
Graph Showing Scores obtained by Subject H.B. on Time Tests



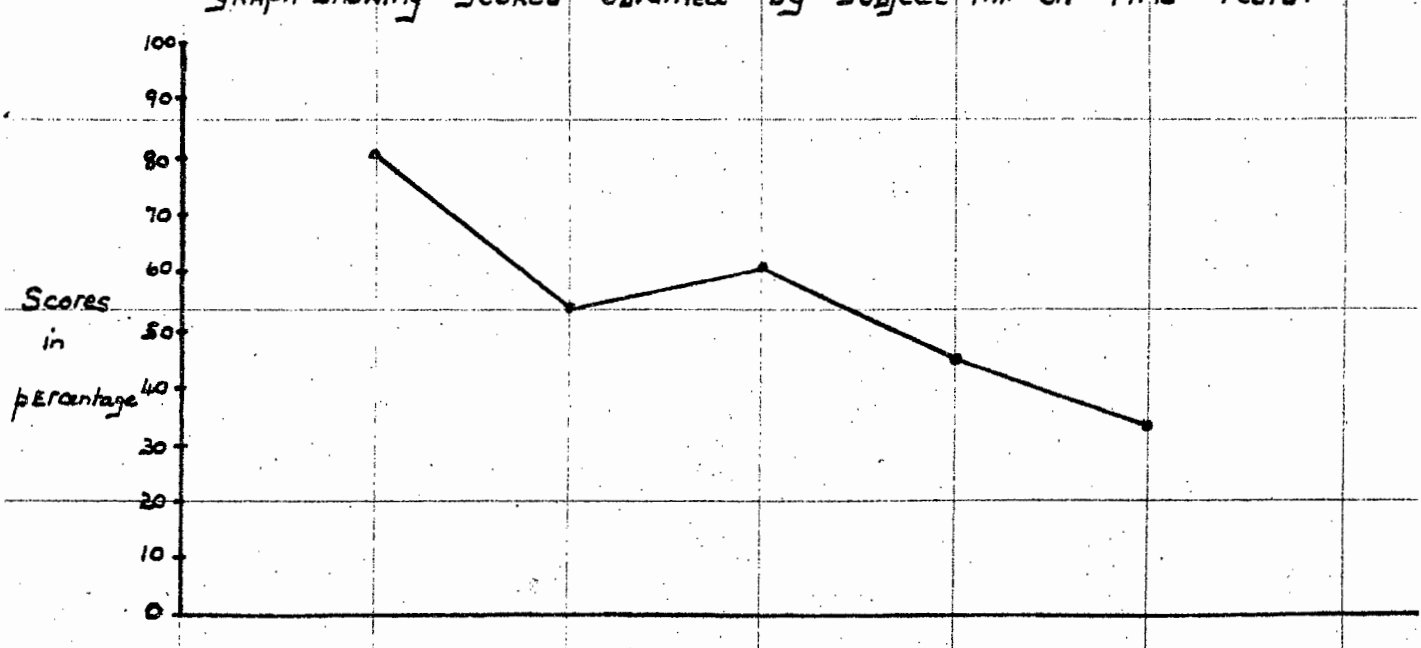
Graph Showing Scores obtained by Subject P.A. on Numbers Test



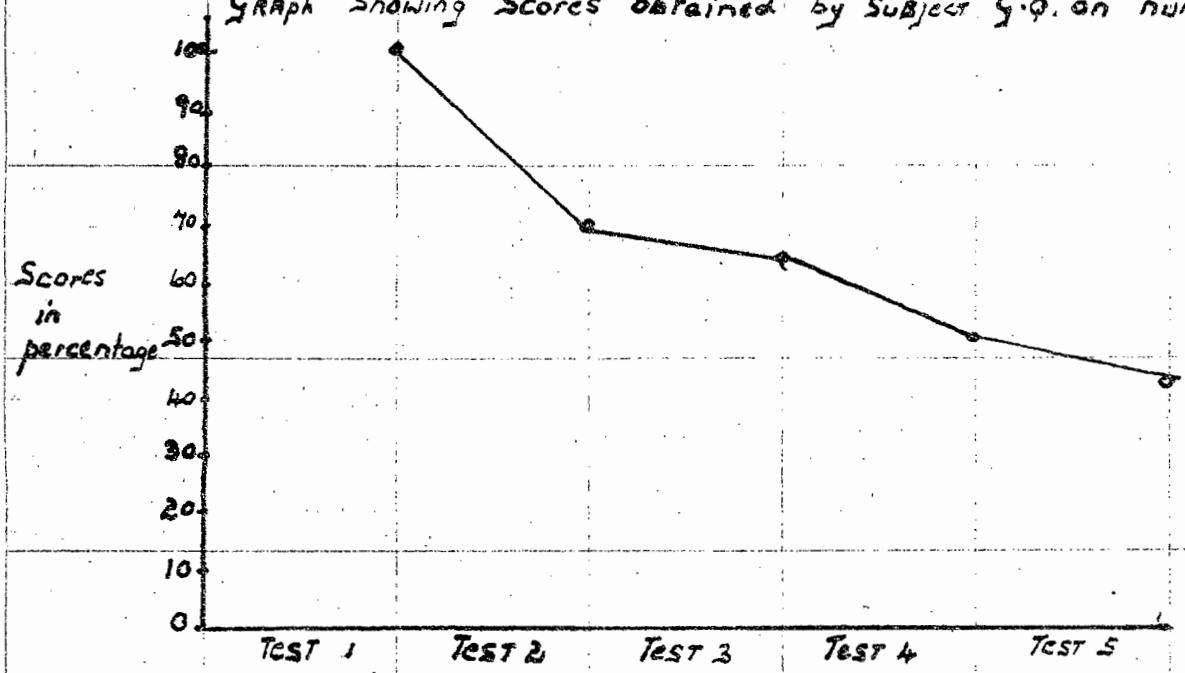
Graph Showing Scores obtained by Subject P.A. on Space Test



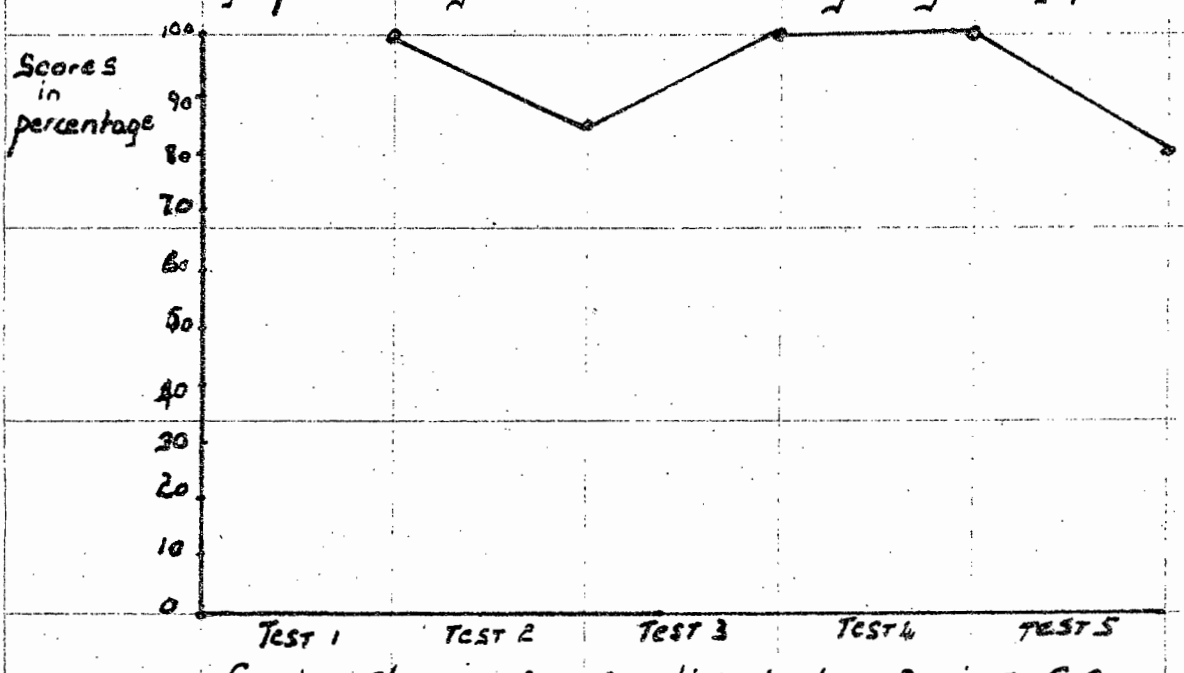
Graph Showing Scores obtained by Subject P.A. on Time Tests.



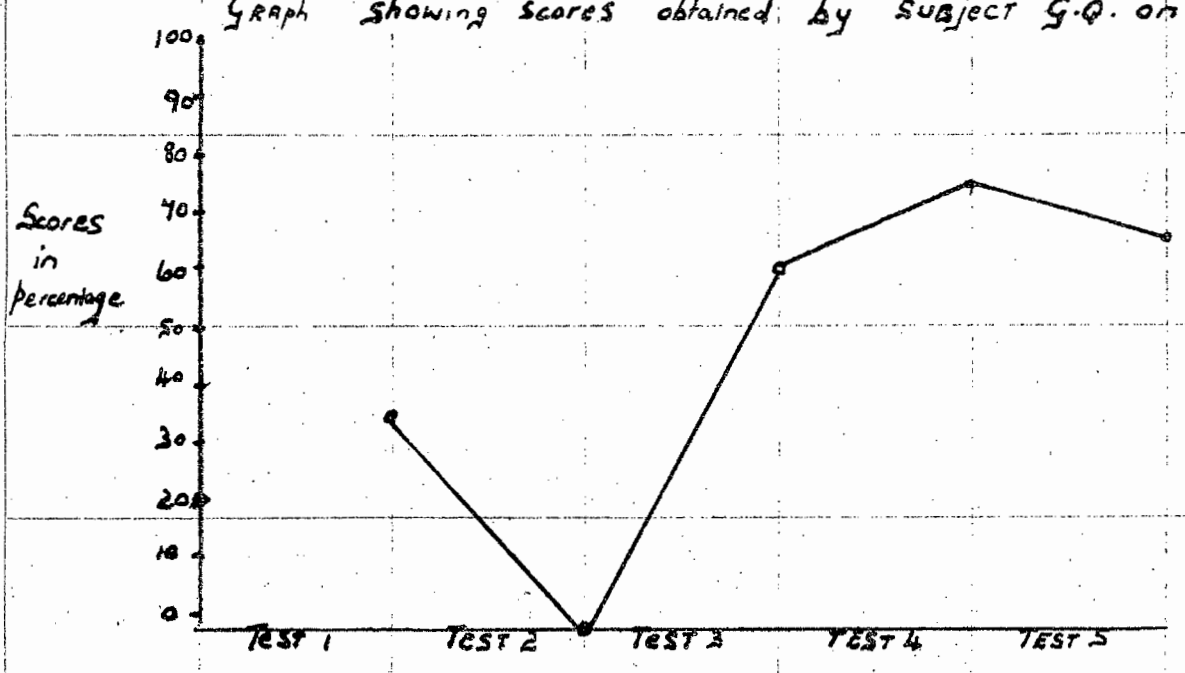
Graph Showing Scores obtained by Subject G.Q. on number Tests.



Graph Showing Scores obtained by Subject G.Q. on Space Tests

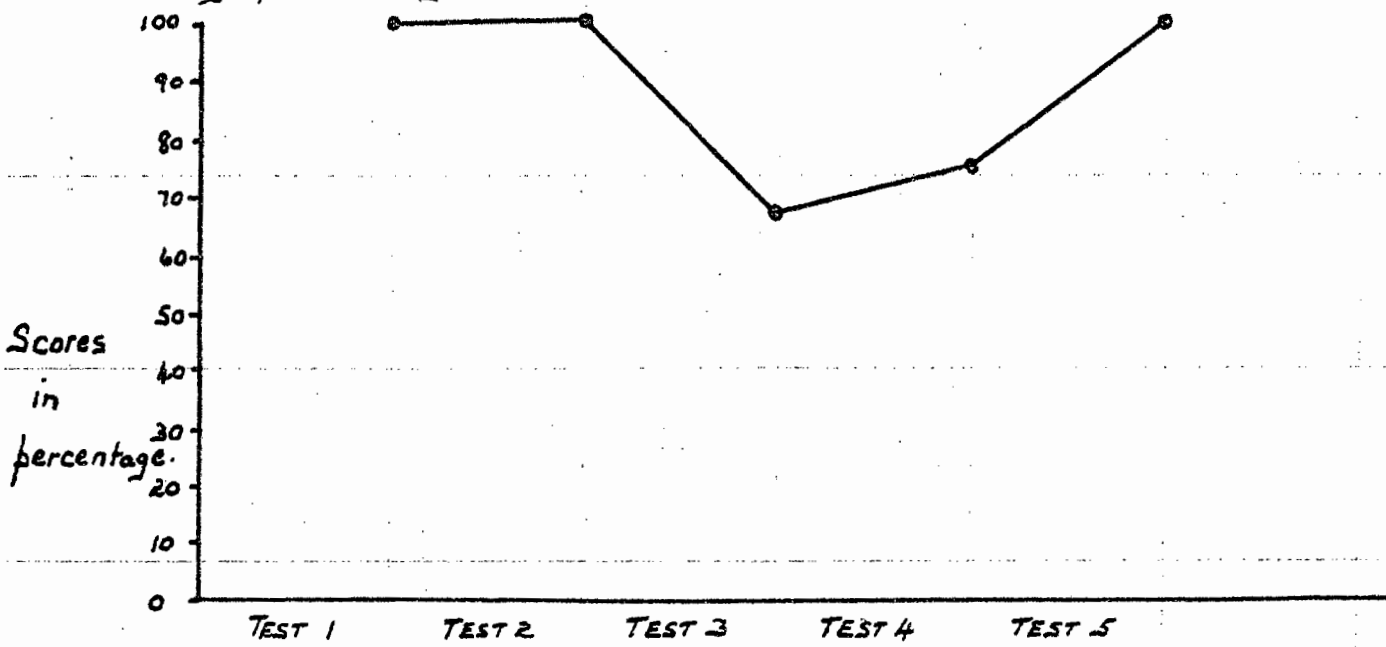


Graph Showing Scores obtained by Subject G.Q. on Time Tests

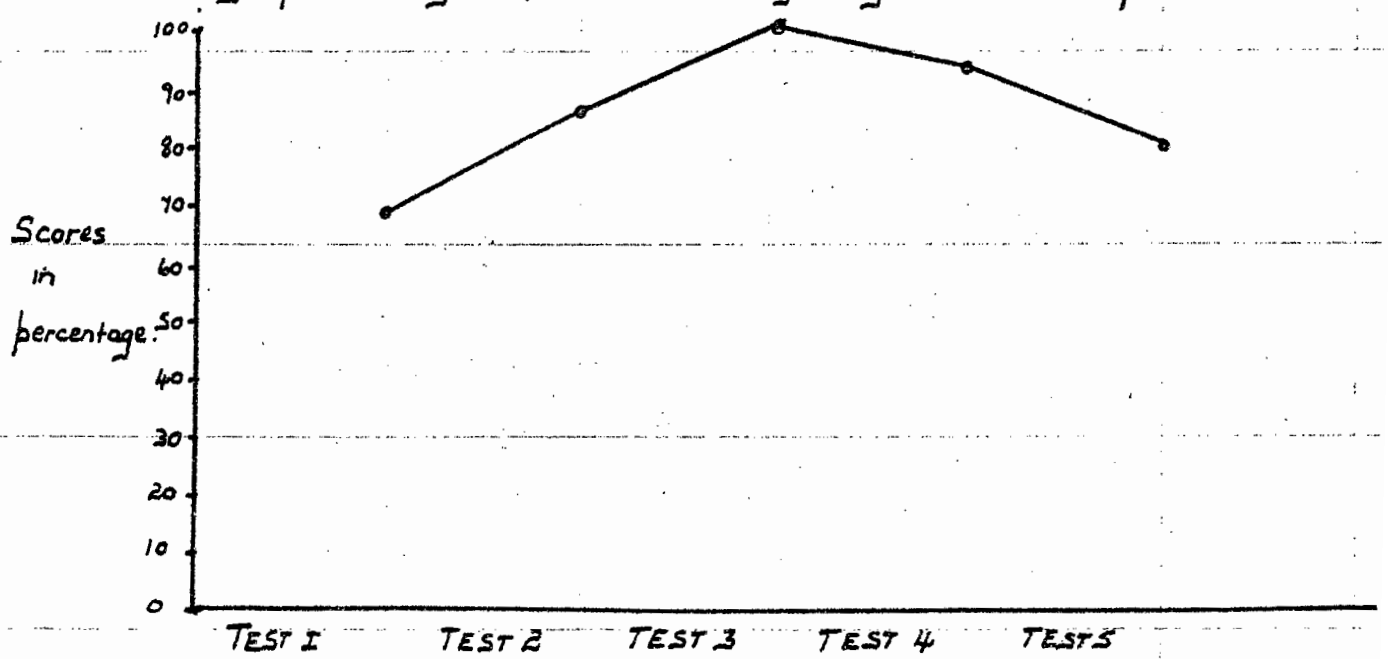


GRAPHS REPRESENTING RESULTS OF FOUR SUBJECTS DRAWN FROM SUB B. GROUP.

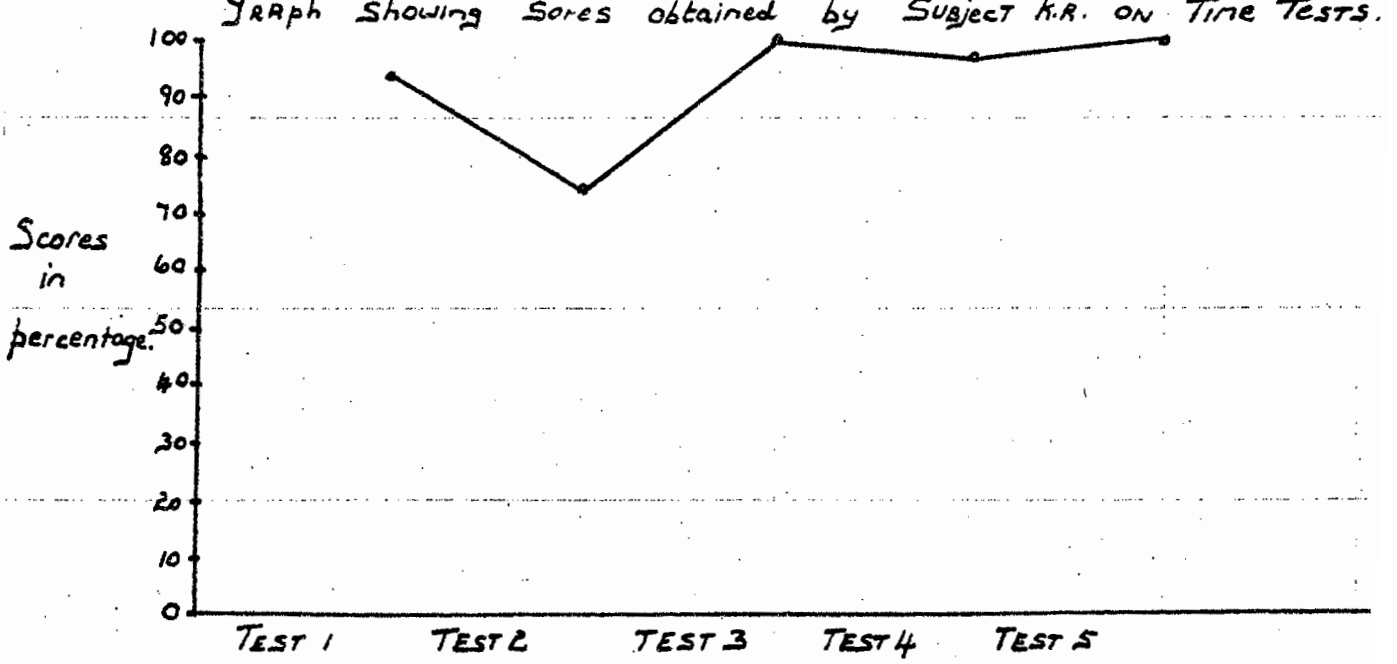
Graph Showing Scores obtained by Subject KR on Number Tests



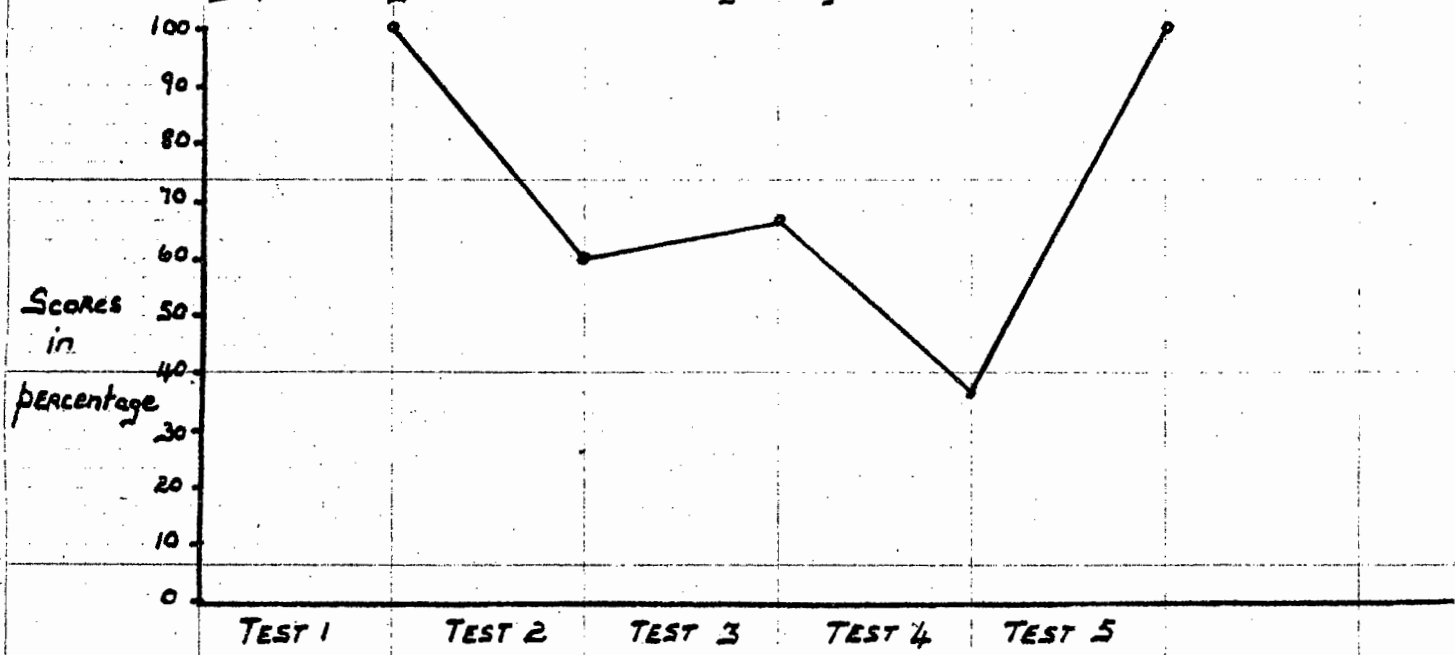
Graph Showing Scores obtained by Subject K.R. on Space Tests.



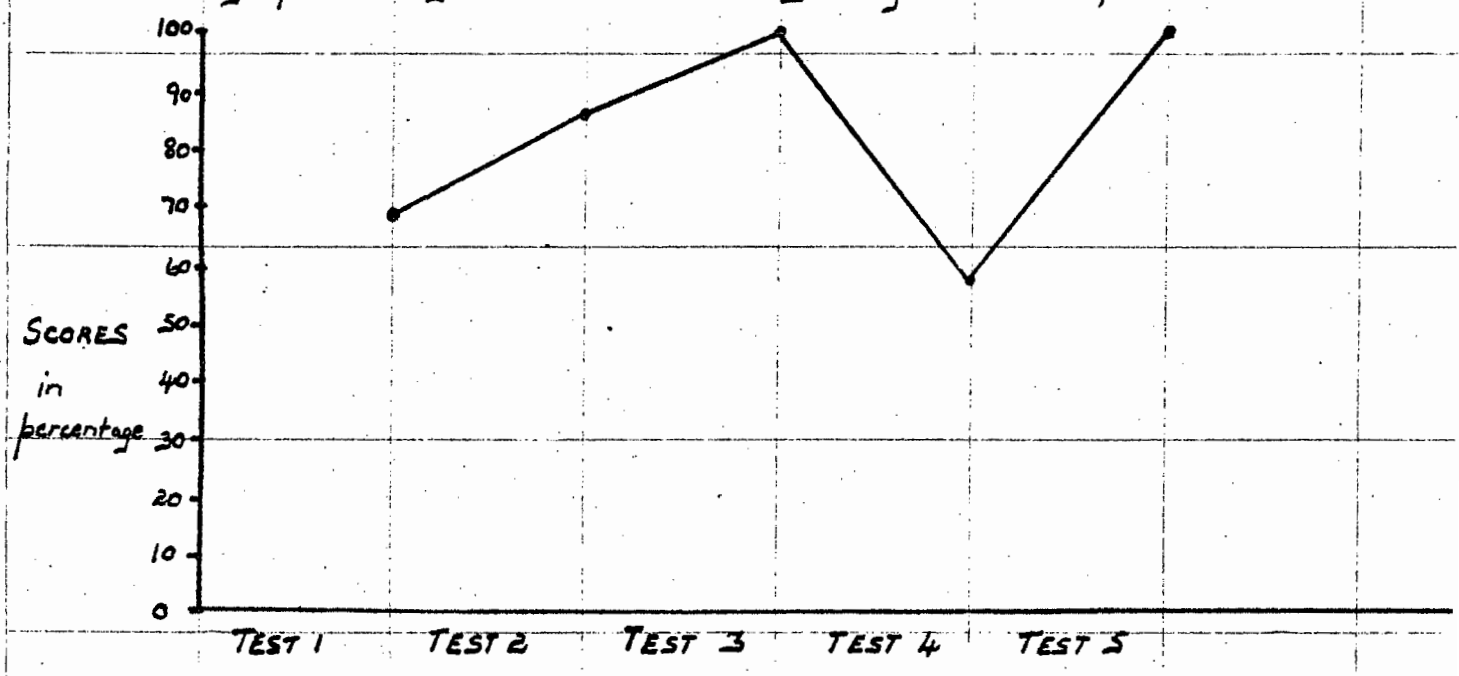
Graph Showing Scores obtained by Subject K.R. on Time Tests.



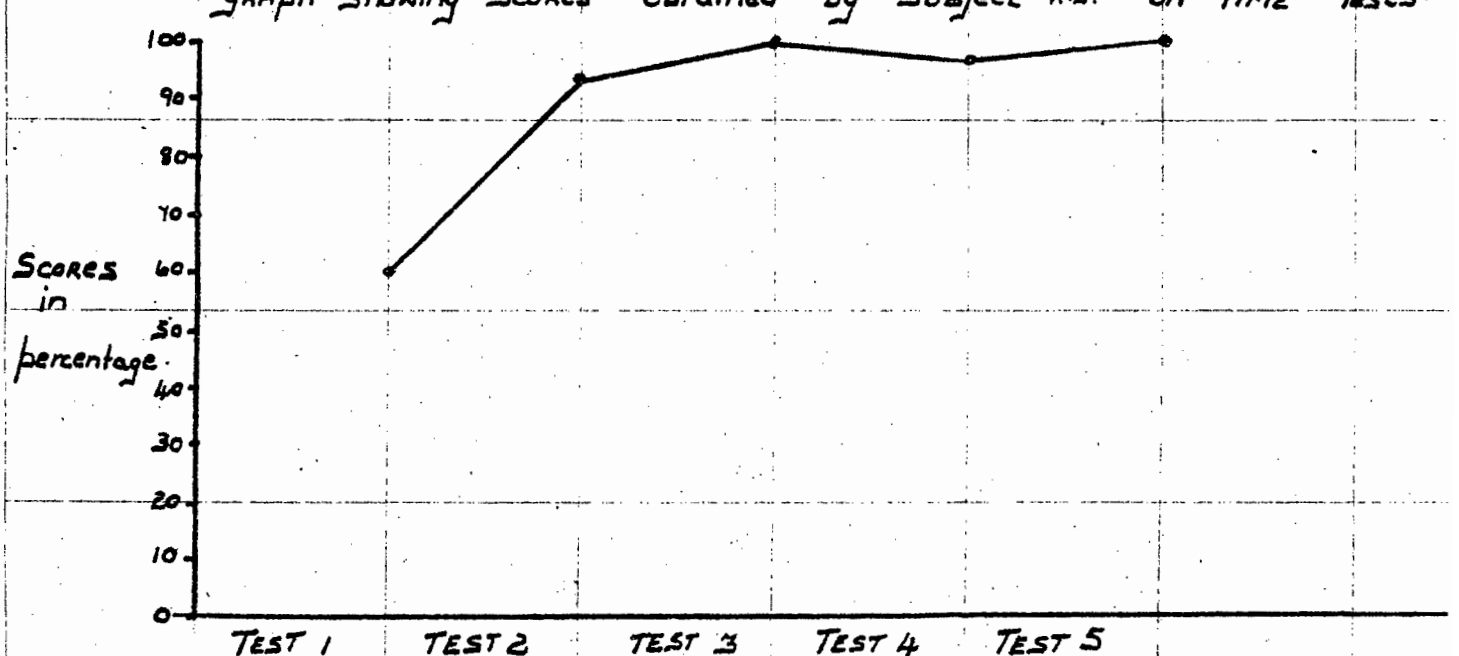
Graph Showing Scores obtained by Subject R.S. on Number Tests



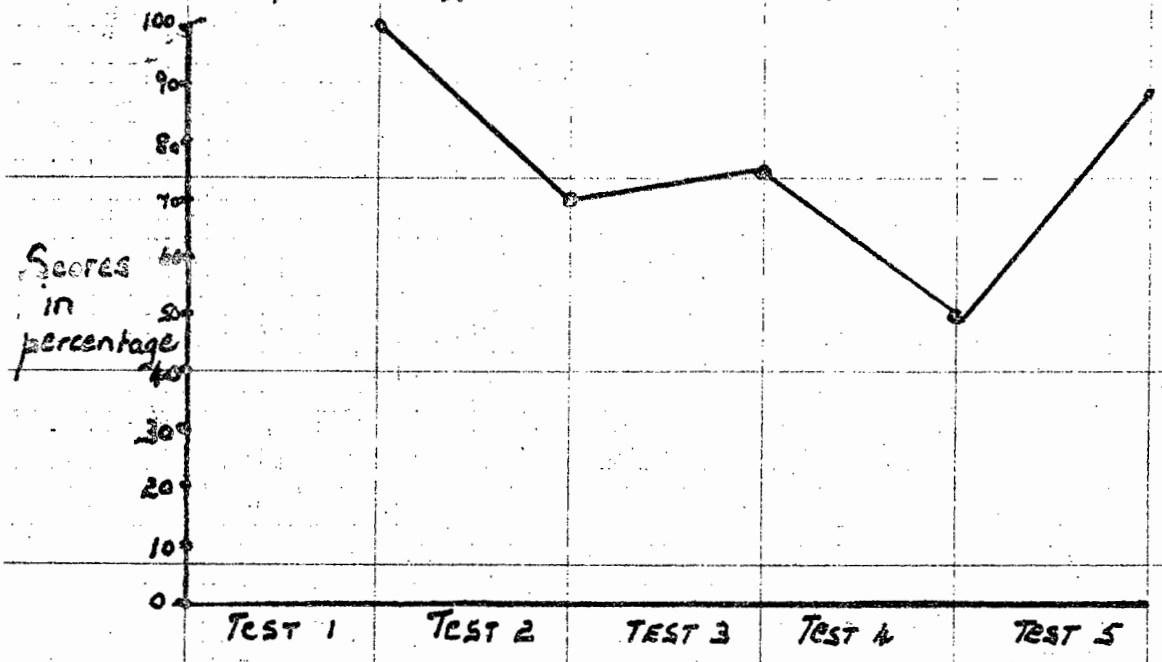
Graph Showing Scores obtained by Subject R.S on Space Tests



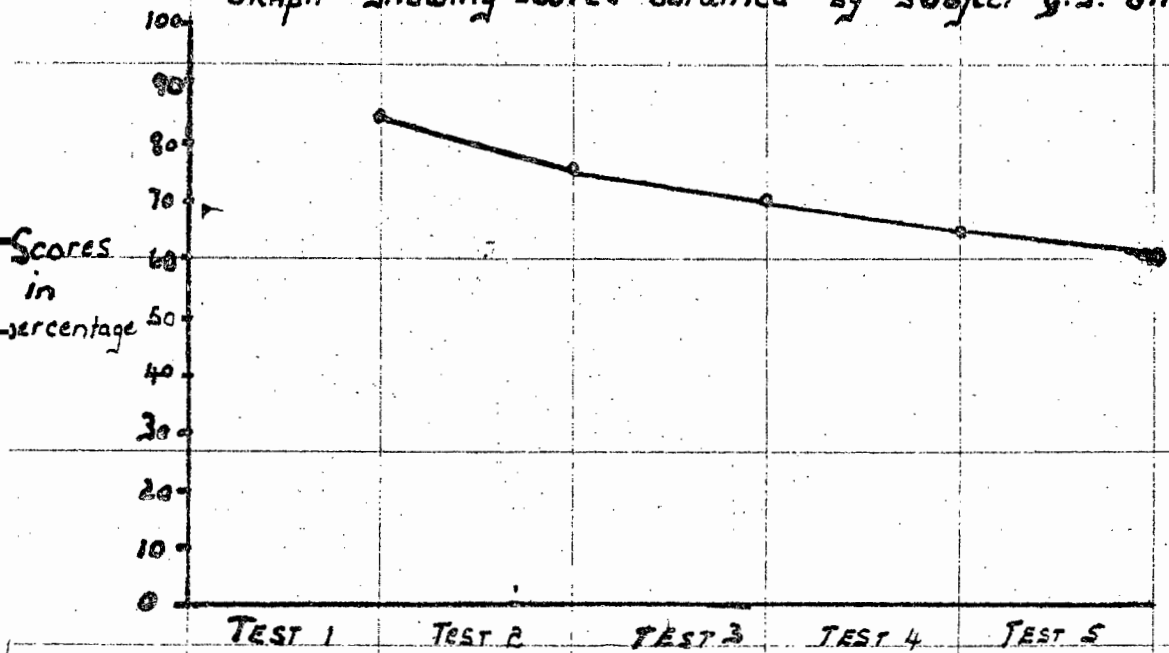
Graph Showing Scores obtained by Subject R.S. on Time Tests.



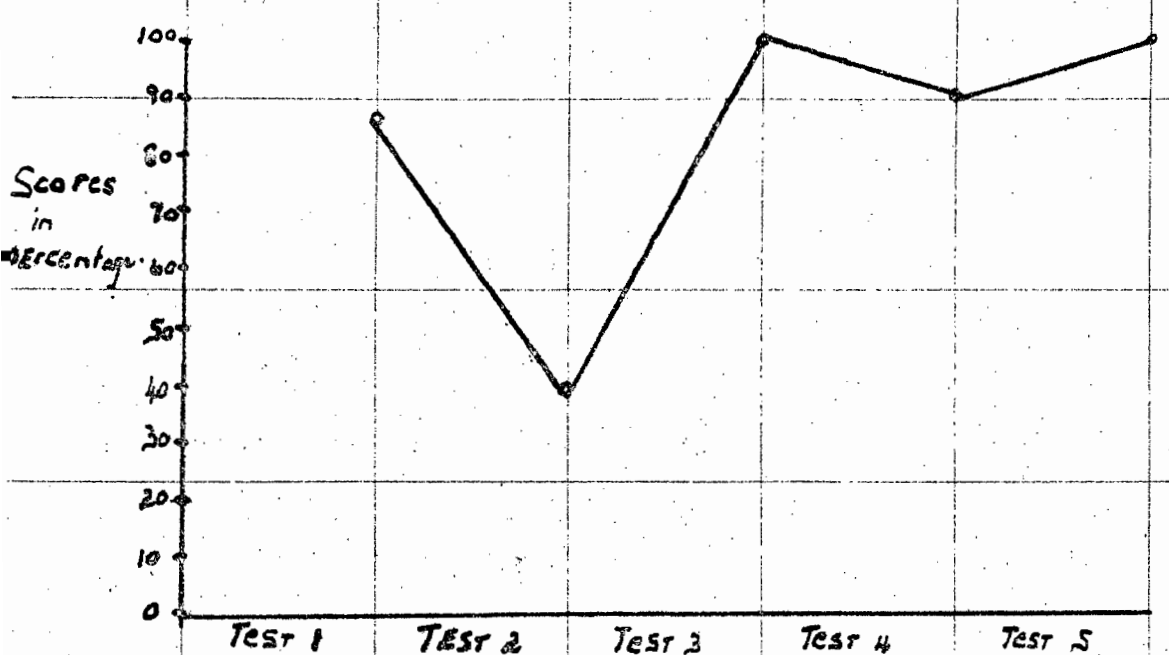
Graph Showing Scores obtained by Subject G.S. on Number Tests



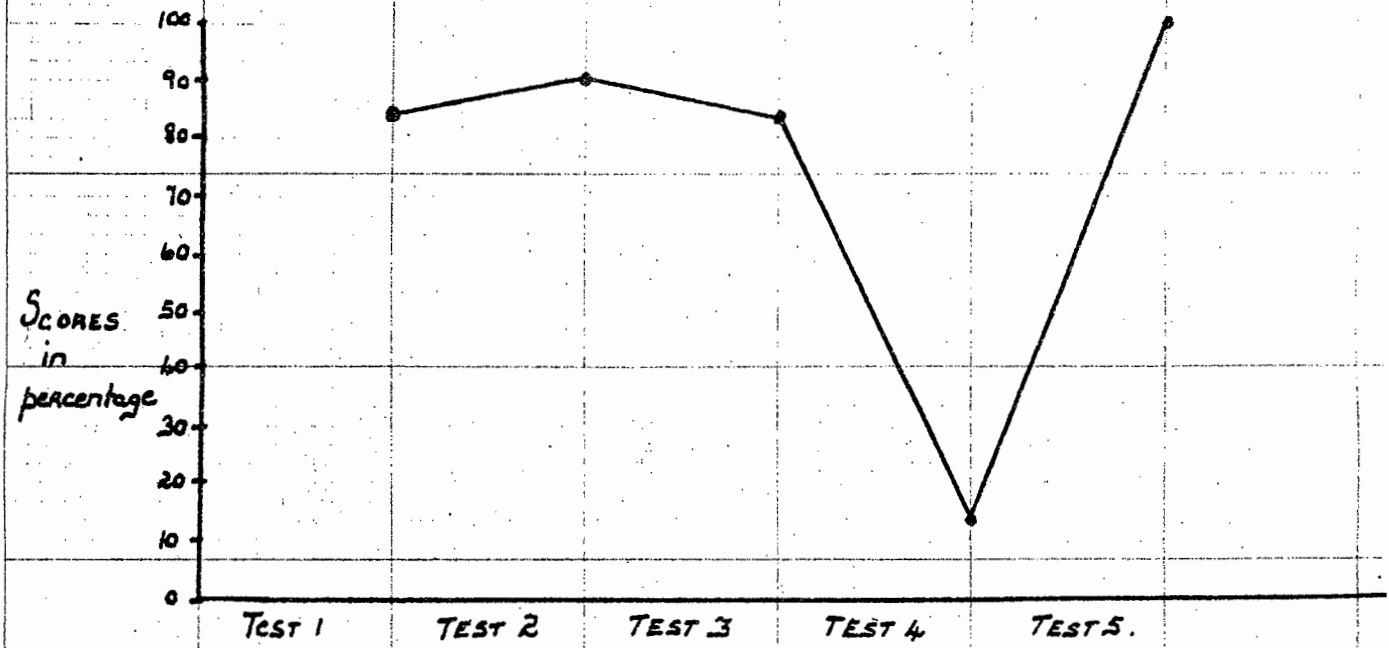
Graph Showing Scores obtained by Subject G.S. on Space Tests



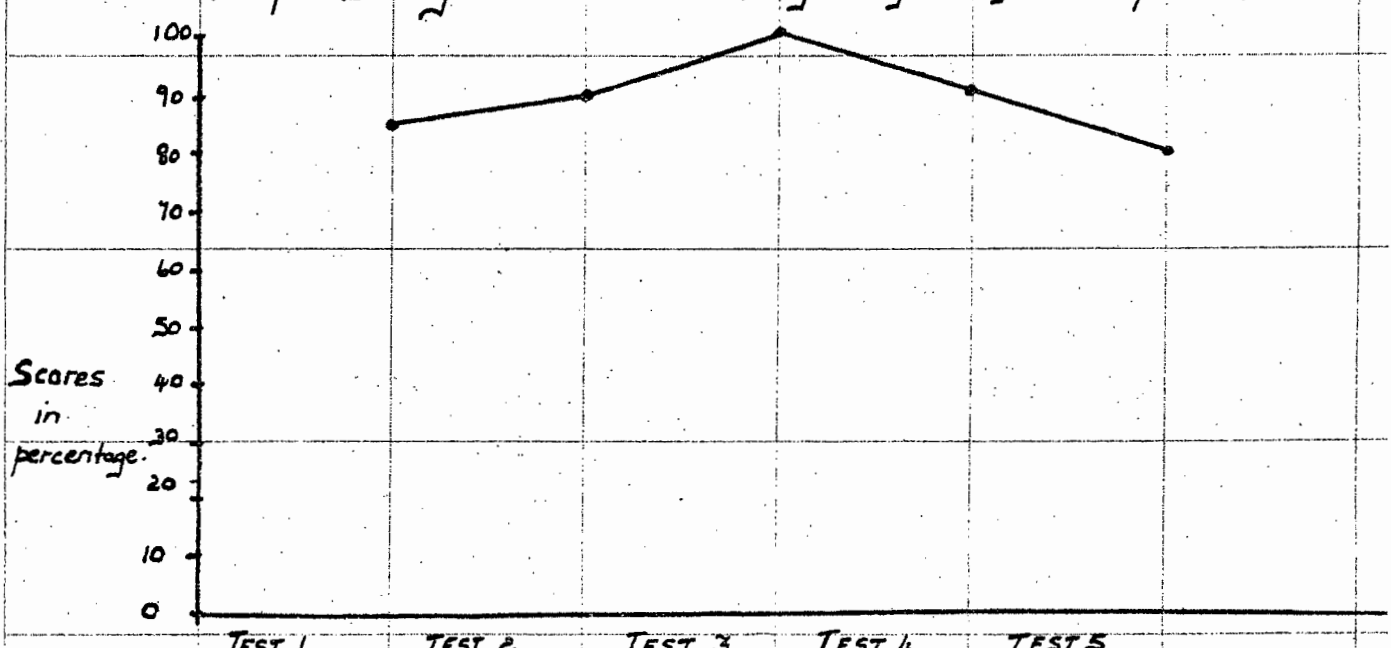
Graph showing scores obtained by Subject G.S. on Time Tests.



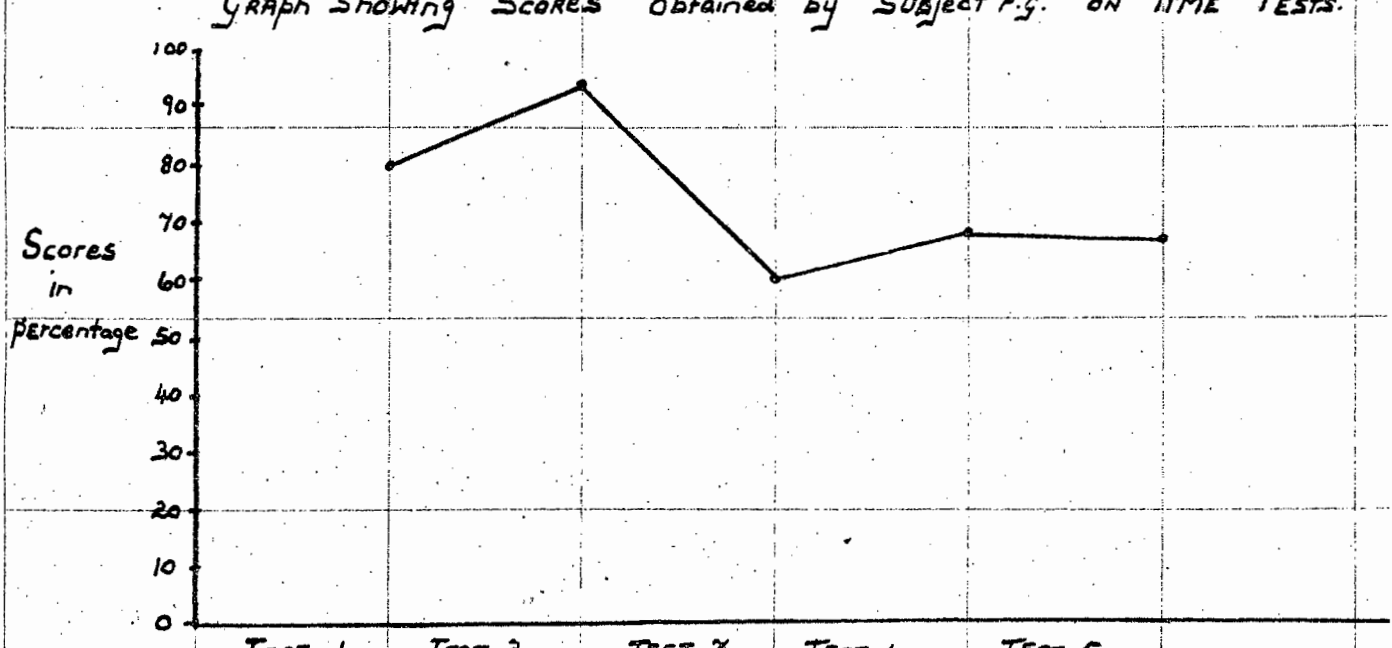
GRAPH Showing SCORES obtained by SUBJECT P.G. ON NUMBER TESTS



GRAPH Showing SCORES obtained by SUBJECT P.G. on SPACE TESTS.

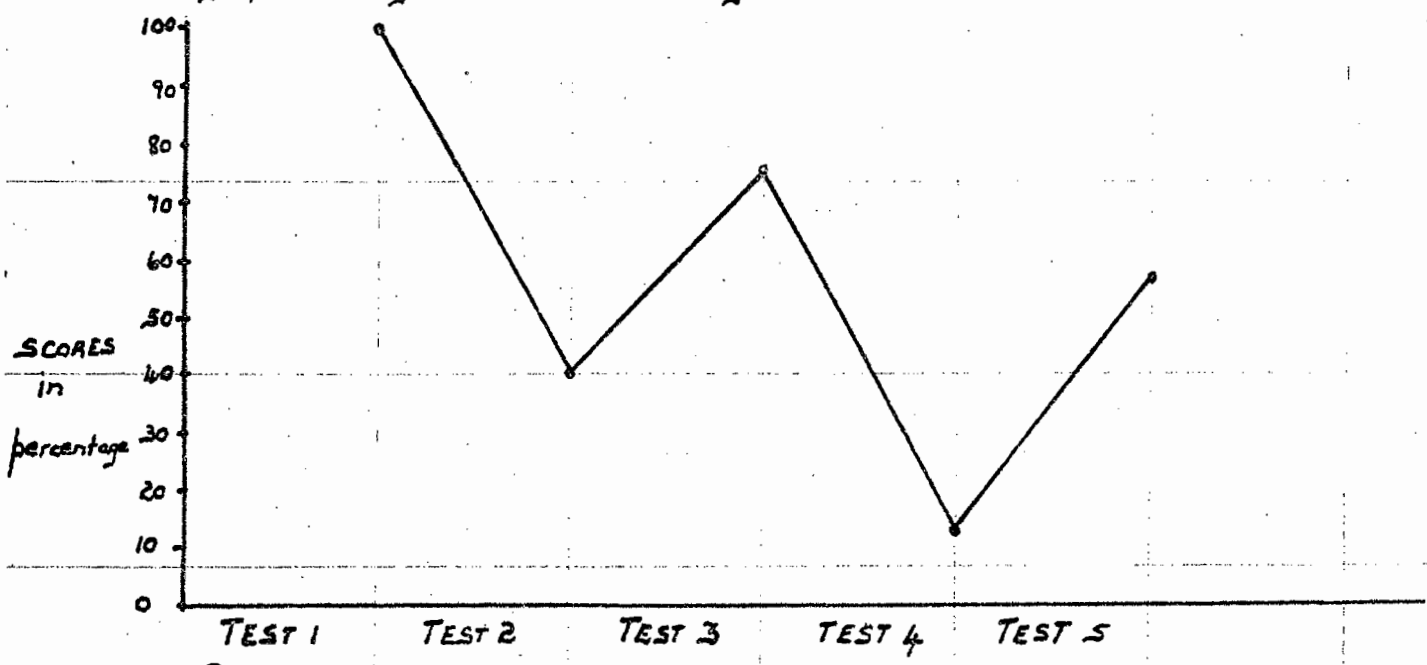


GRAPH Showing SCORES obtained by SUBJECT P.G. ON TIME TESTS.

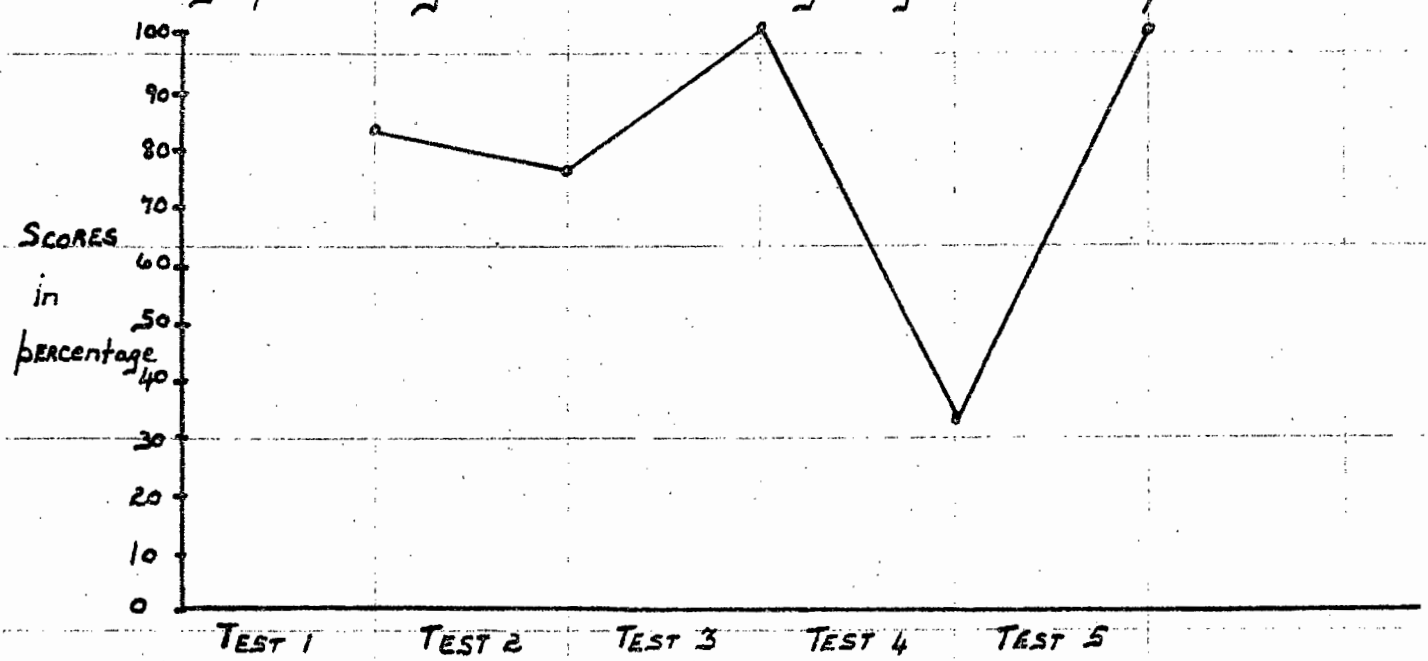


GRAPHS REPRESENTING RESULTS OF FOUR SUBJECTS DRAWN FROM STANDARD I GROUP.

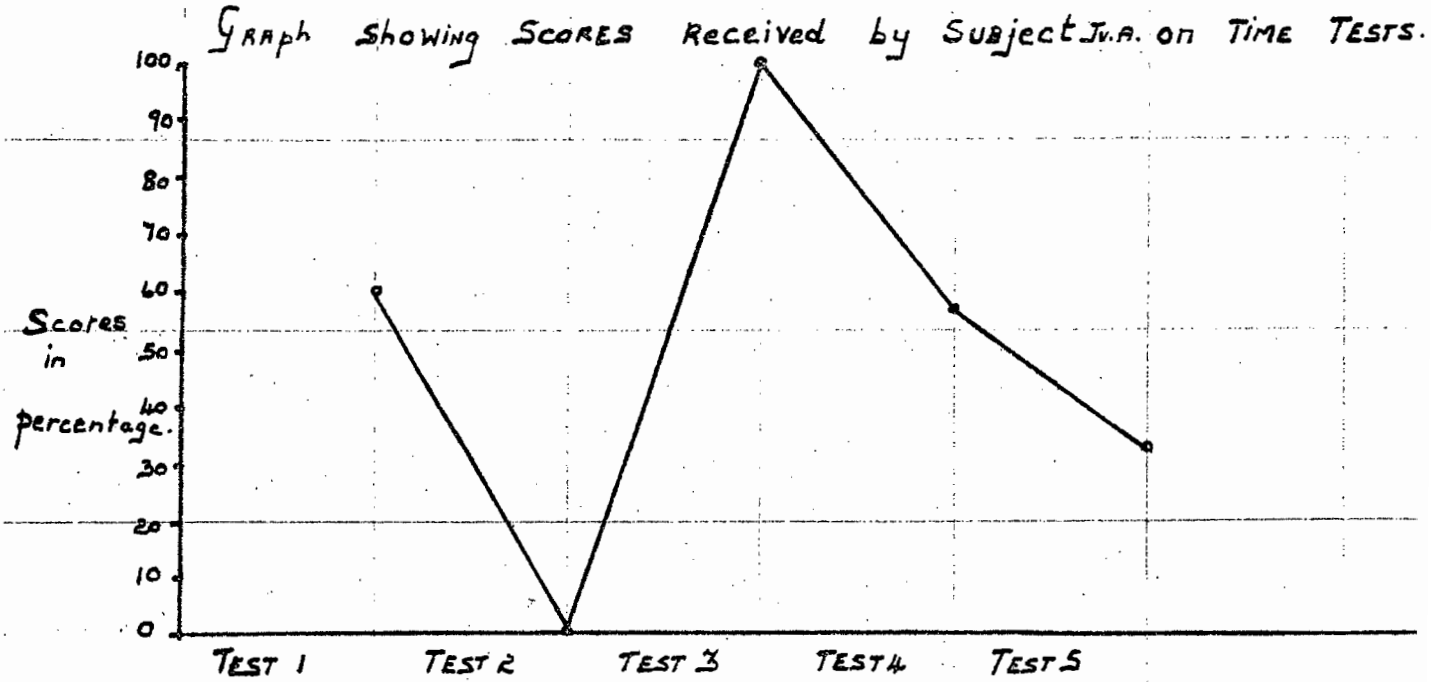
Graph showing scores obtained by Subject J.v.A. on Number Tests



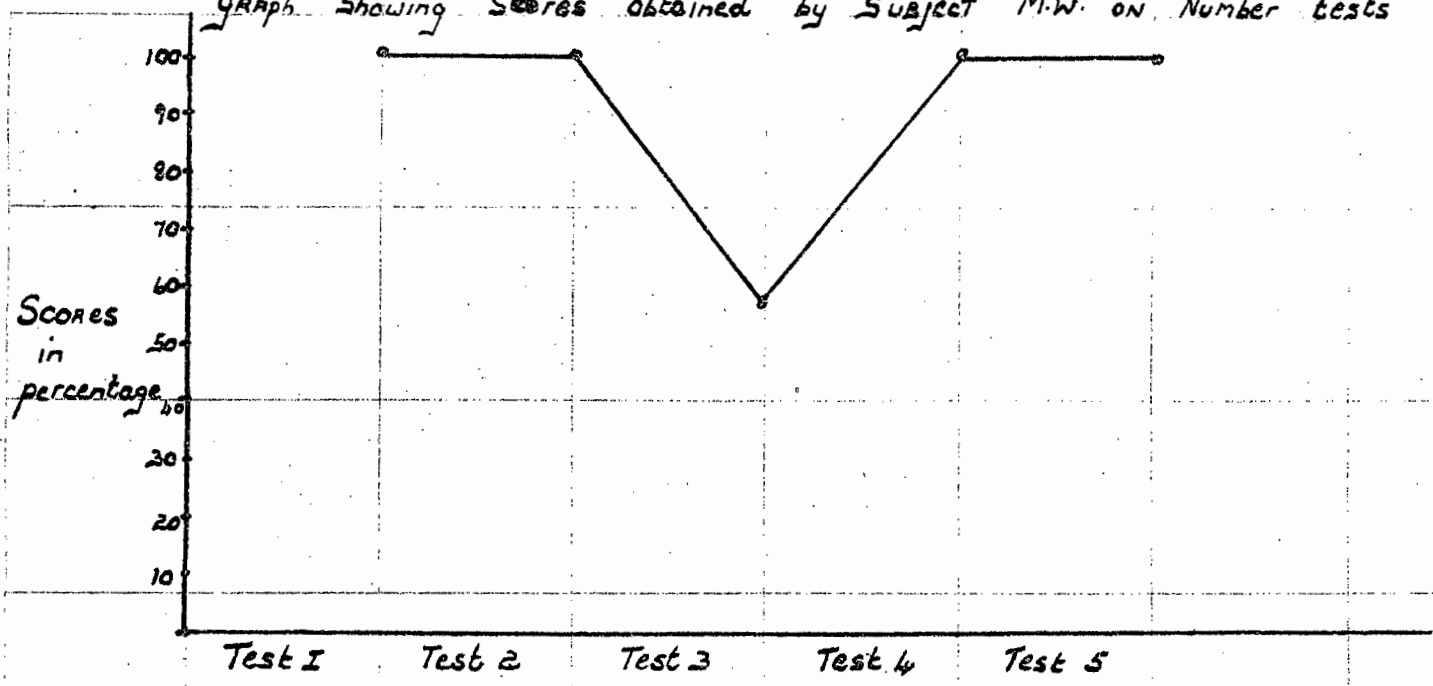
Graph showing scores obtained by Subject J.v.A. on Space Tests.



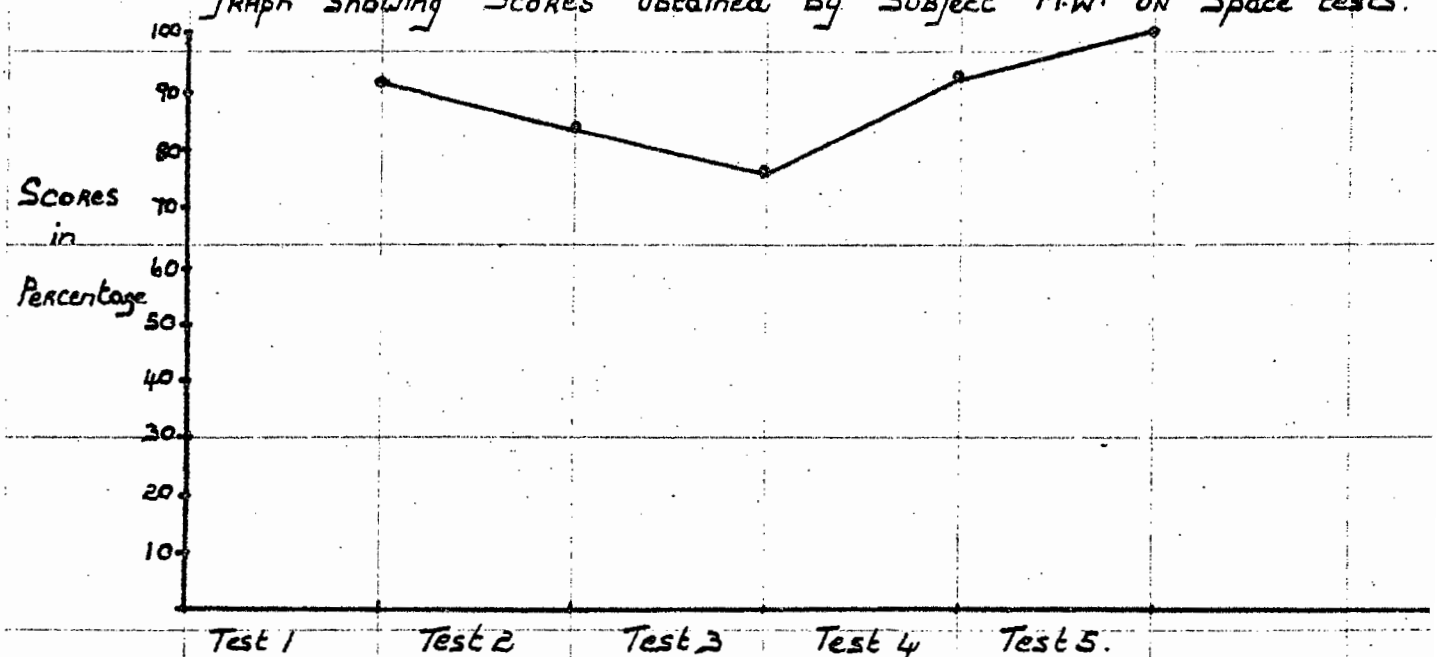
Graph showing scores received by Subject J.v.A. on Time Tests.



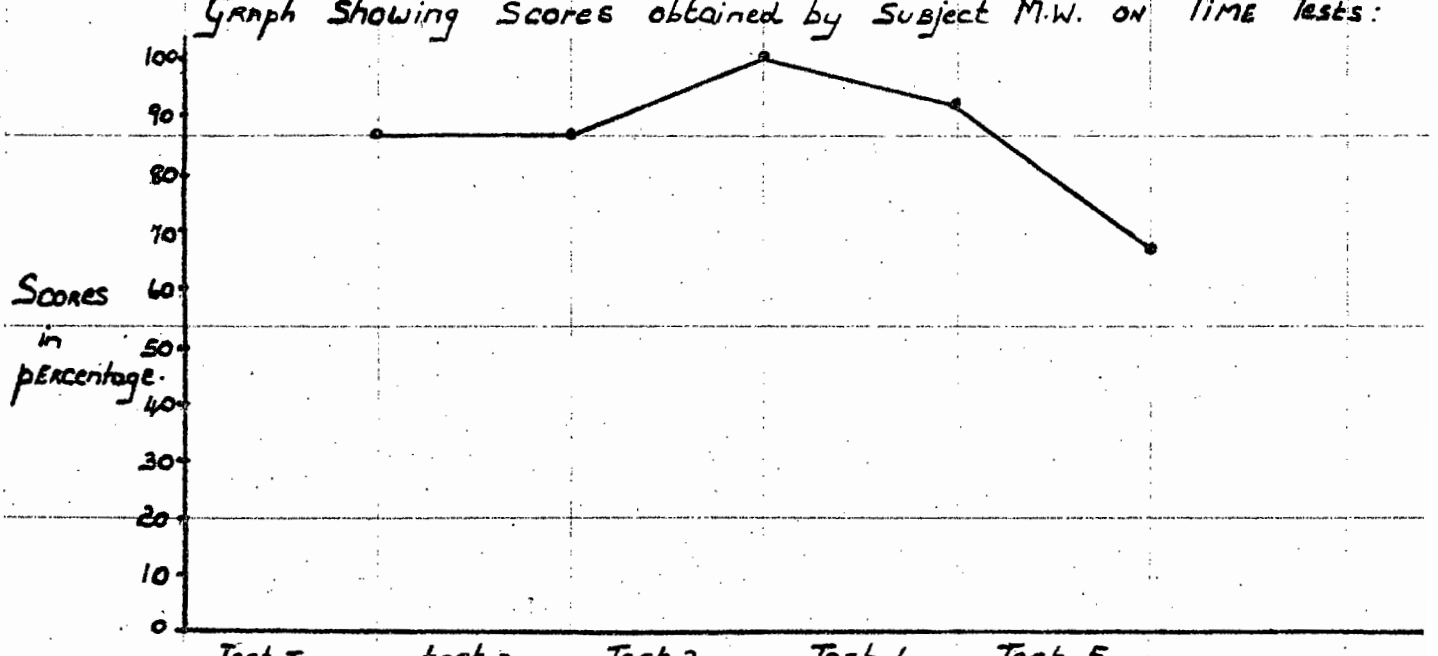
Graph Showing Scores obtained by Subject M.W. on Number tests



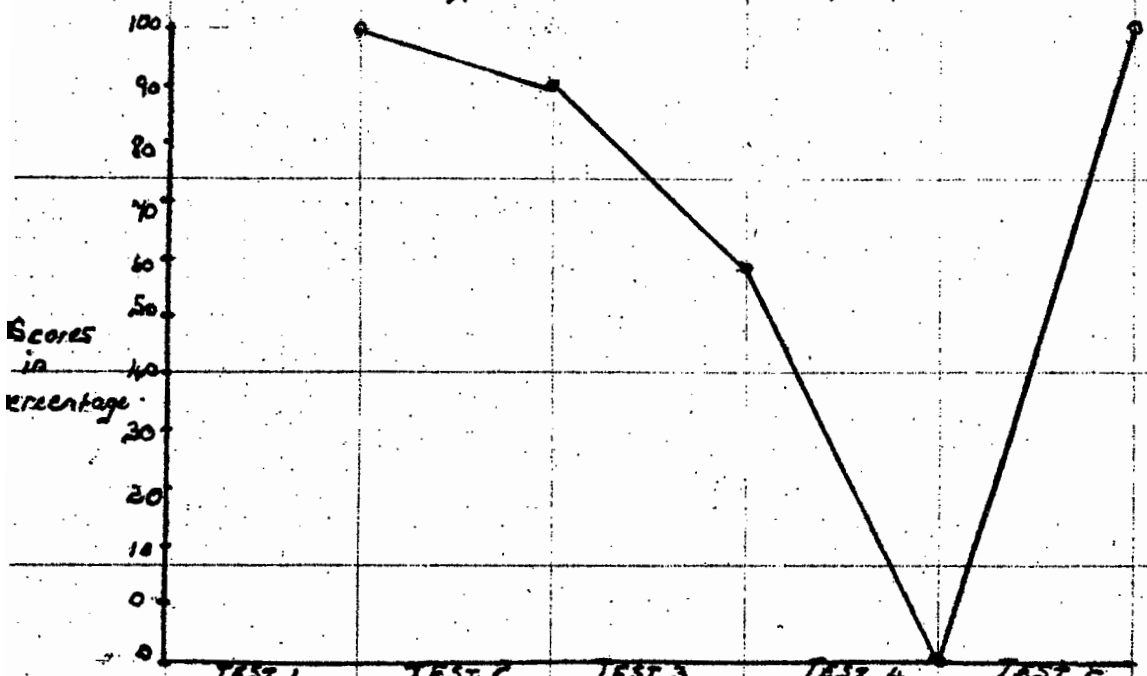
Graph Showing Scores obtained by Subject M.W. on Space tests.



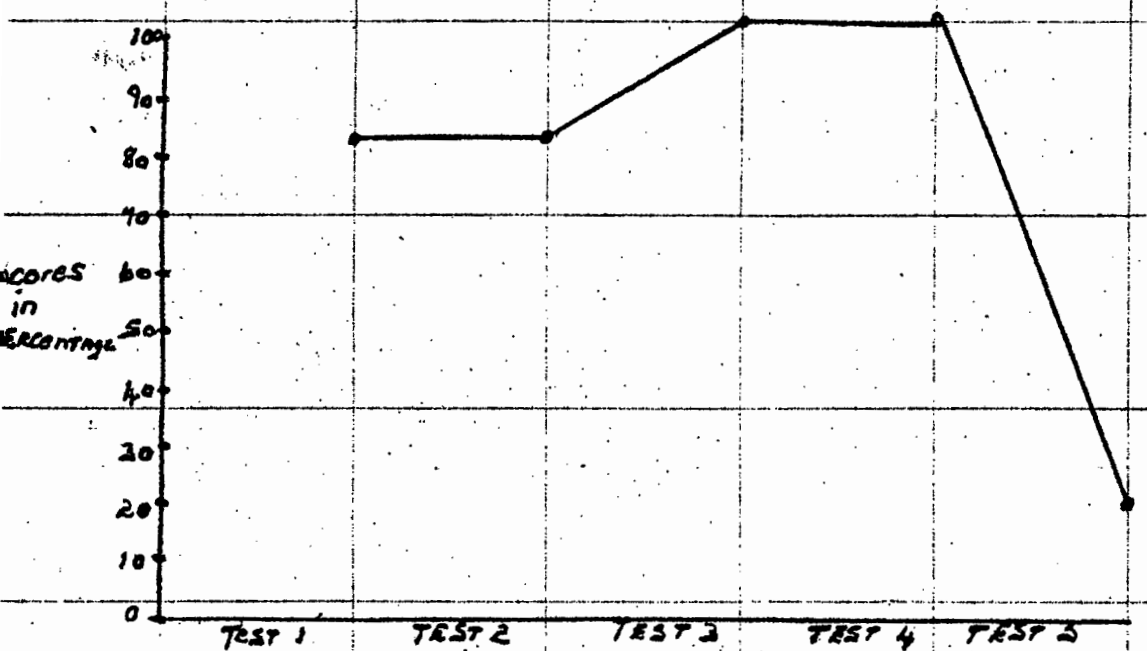
Graph Showing Scores obtained by Subject M.W. on Time Tests:



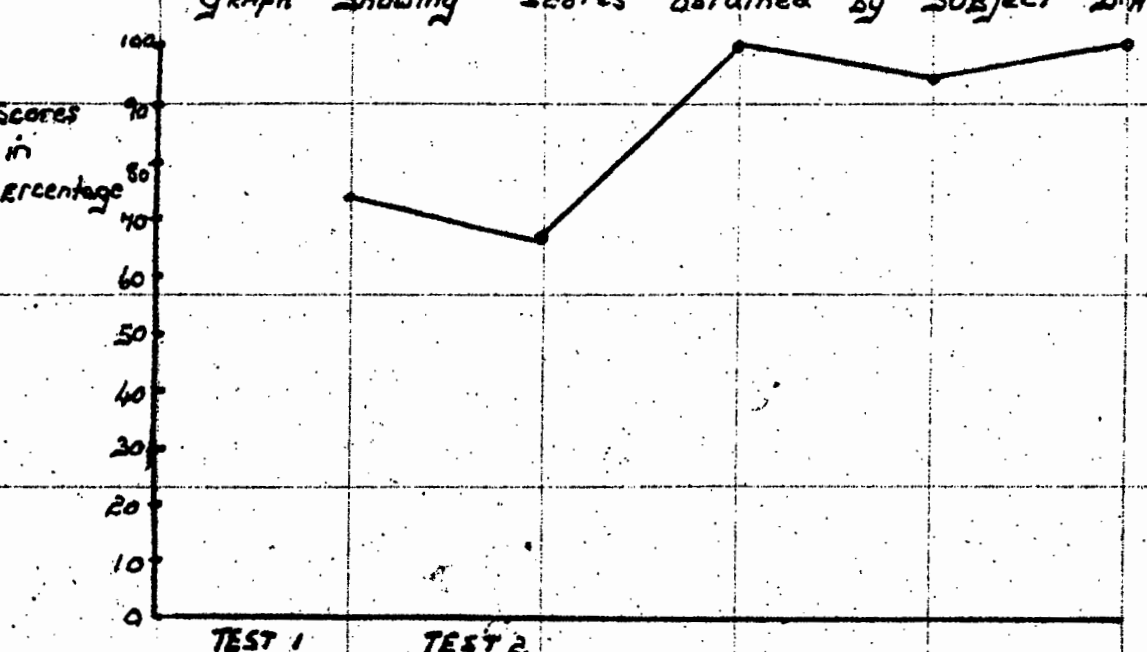
Graph showing Scores obtained by Subject D.H. on Number Tests



Graph Showing Scores obtained by Subject D.H. on Space Tests

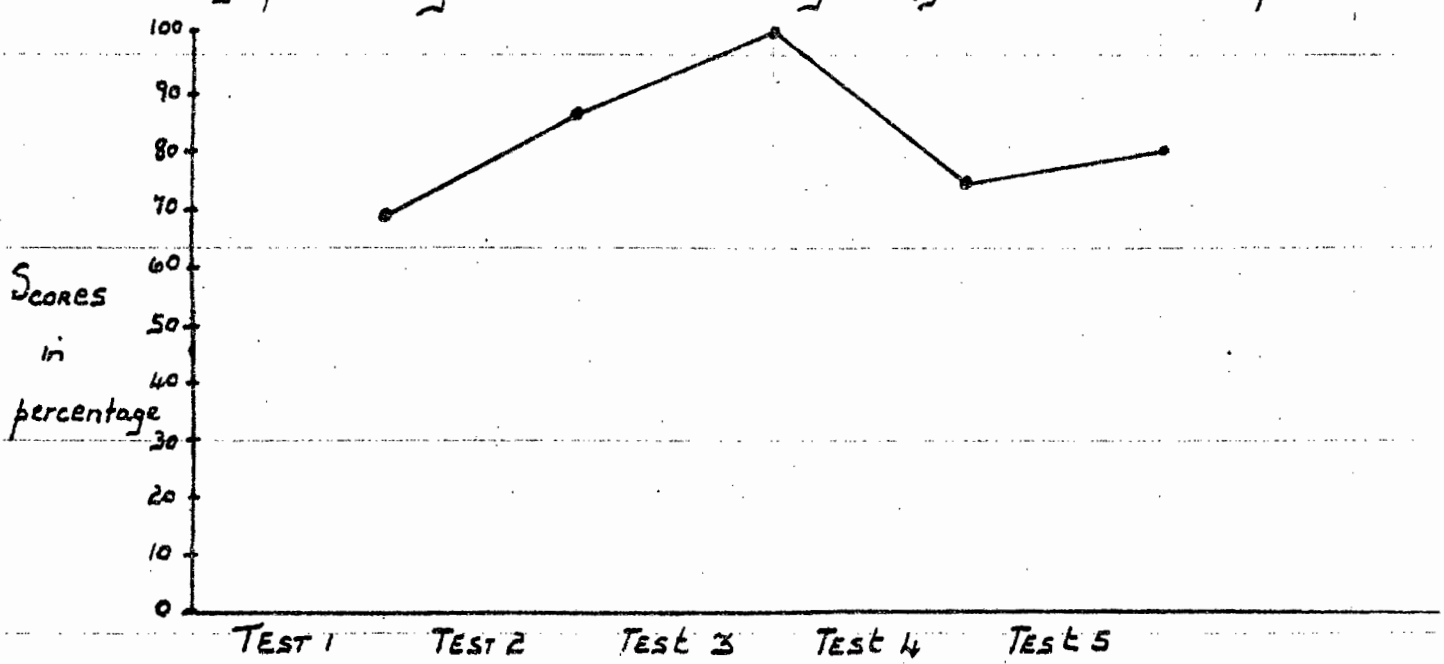


Graph Showing Scores obtained by Subject D.H. on Time Tests

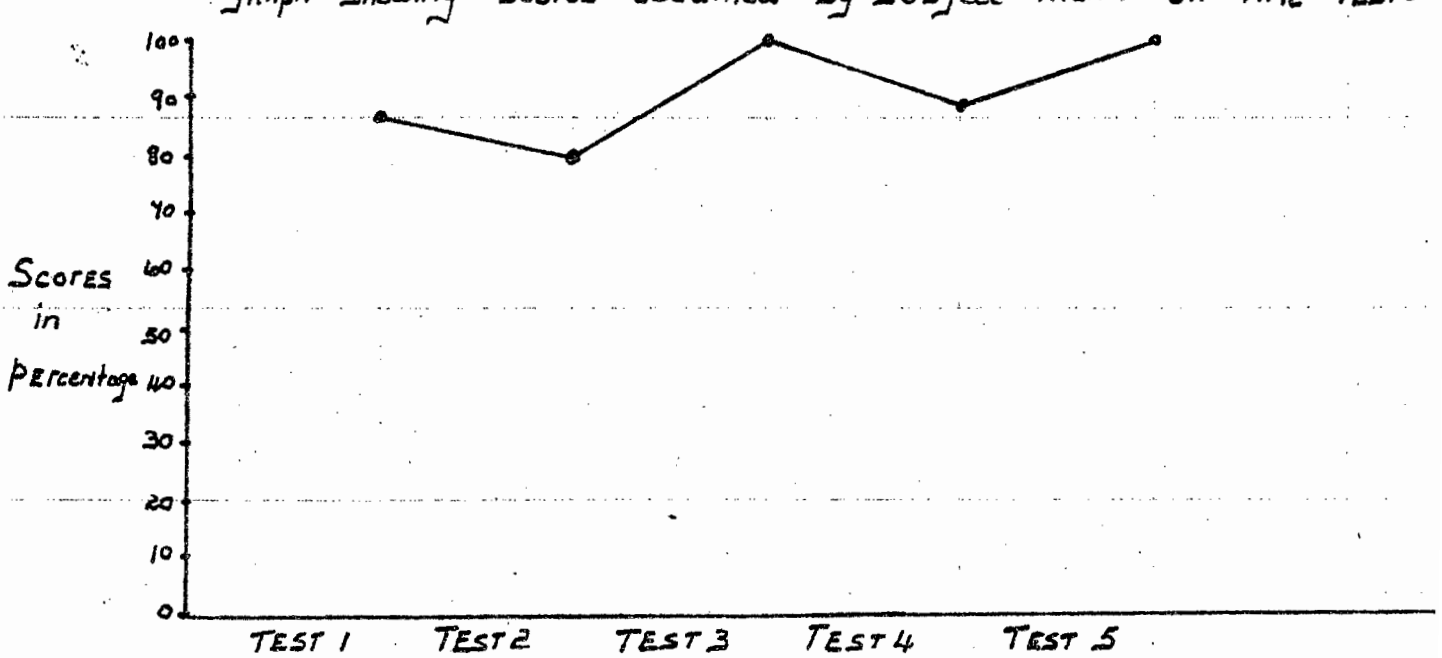


Graph showing scores obtained by subject Kvd. M. on Number tests

Graph showing scores obtained by subject Kvd. M. on Space tests.

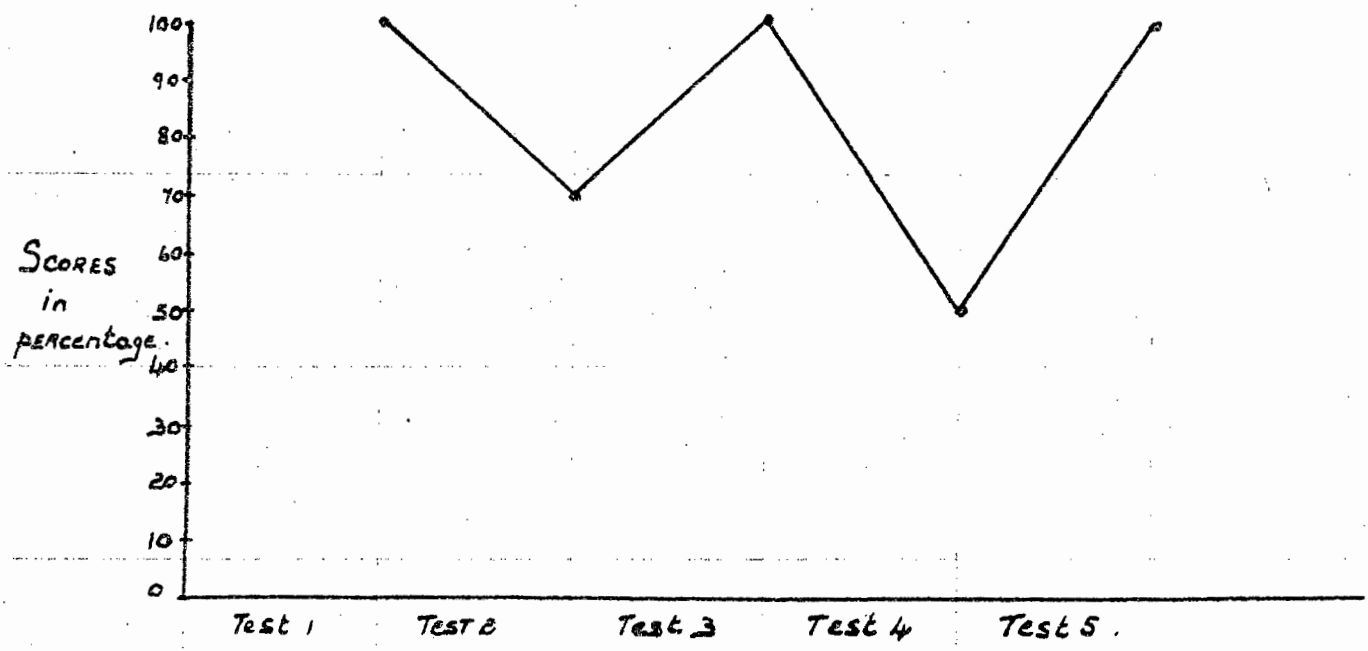


Graph showing scores obtained by subject Kvd. M. on Time tests

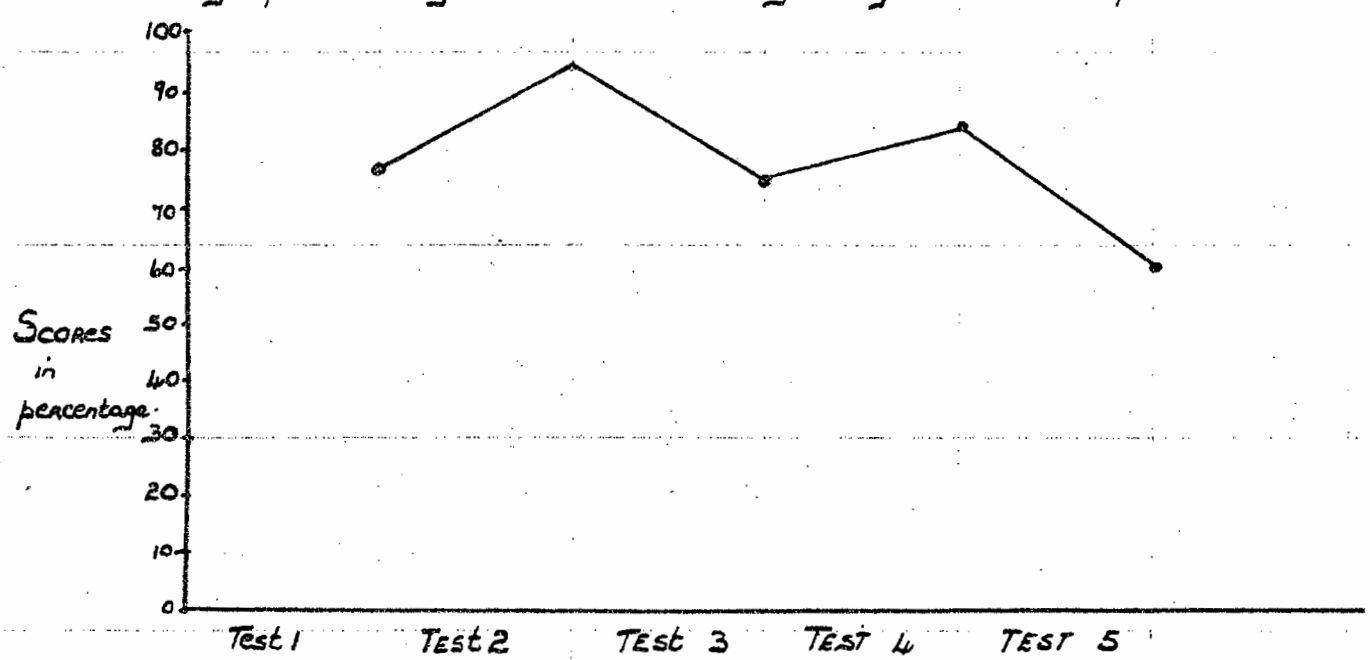


GRAPHS REPRESENTING RESULTS OF FOUR SUBJECTS DRAWN FROM STANDARD II GROUP.

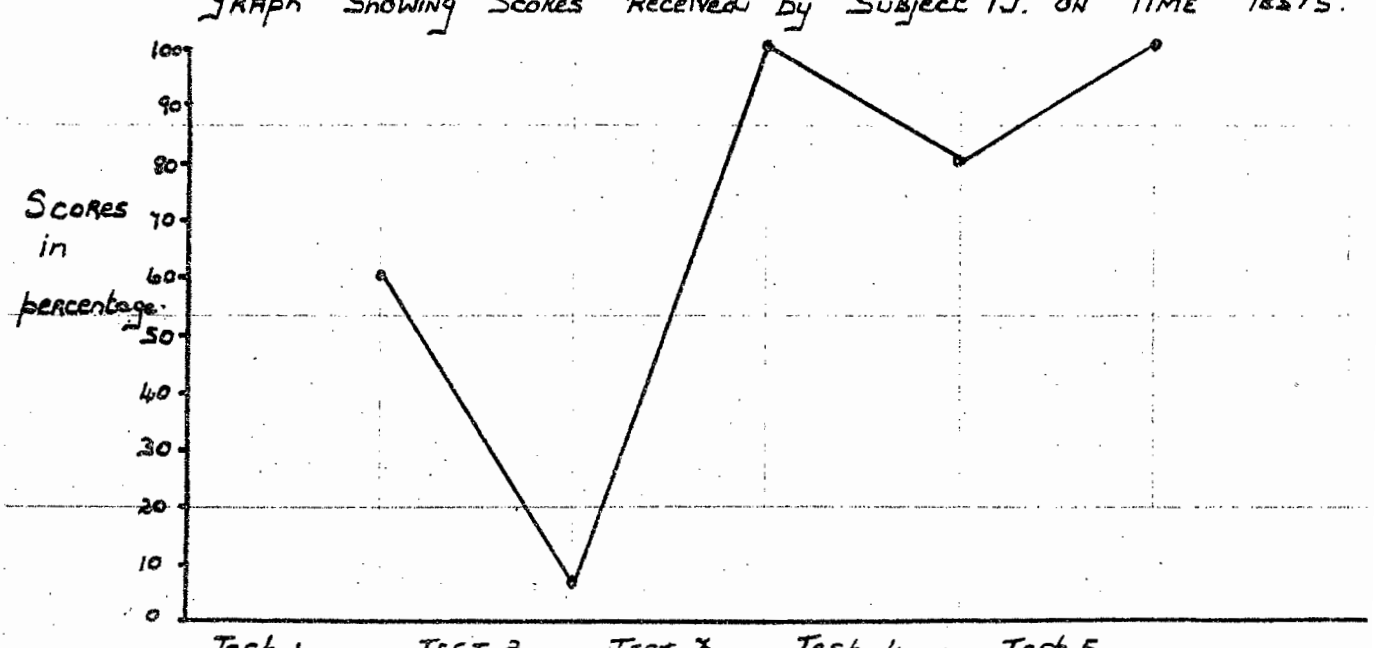
Graph Showing Scores Received By Subject T.J. on Number Tests



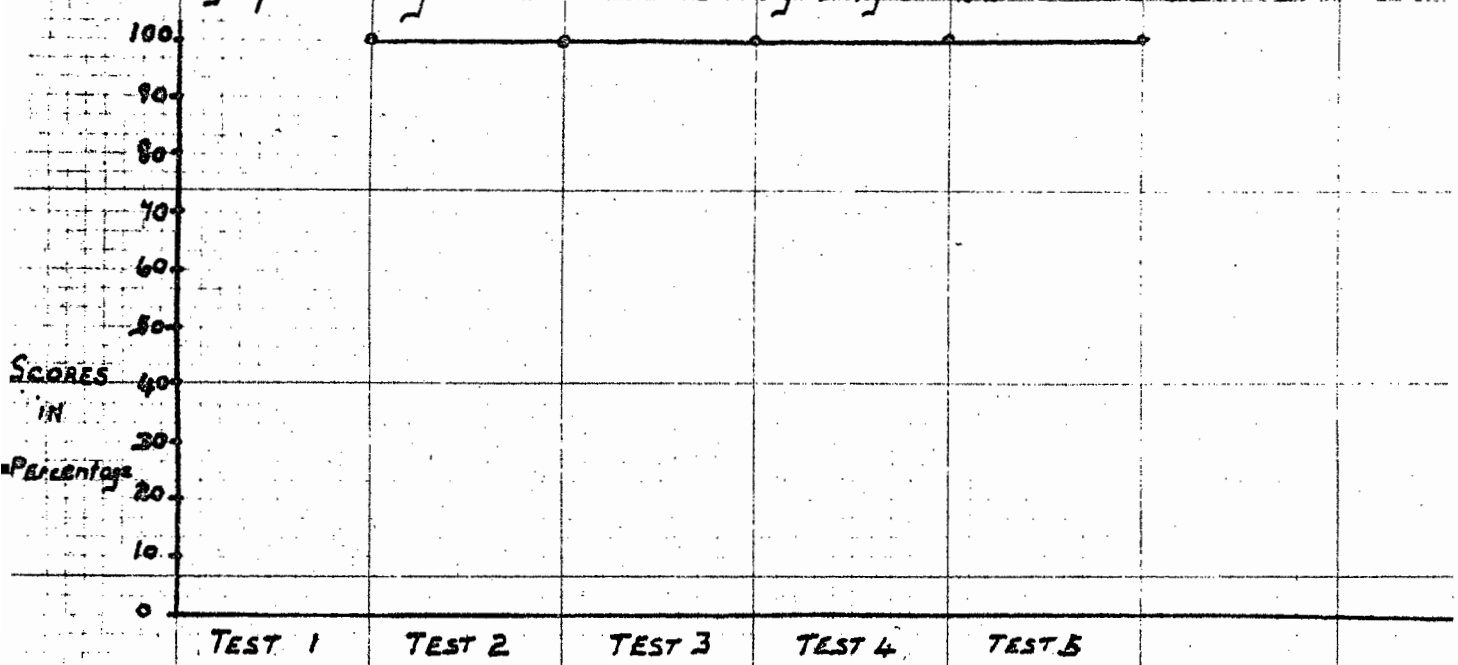
Graph Showing Scores Received By Subject T.J. on Space Tests.



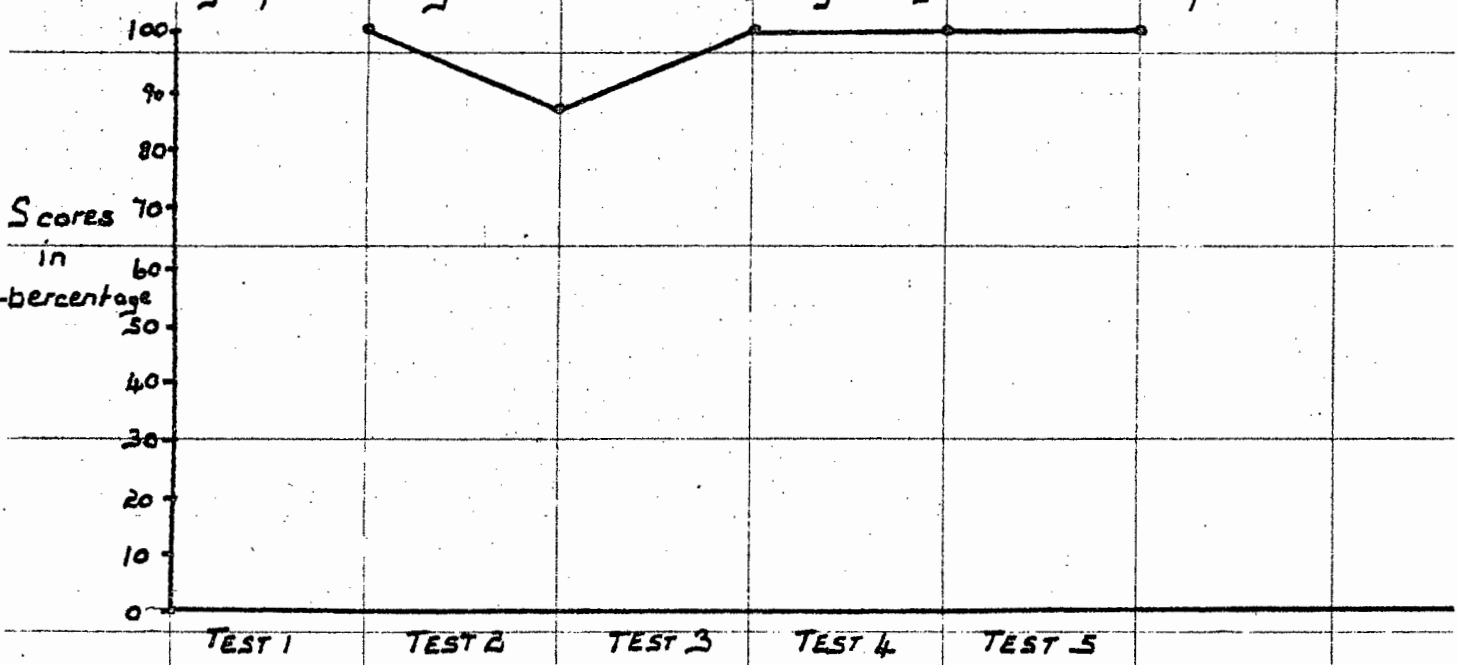
Graph Showing Scores Received by Subject T.J. on Time Tests.



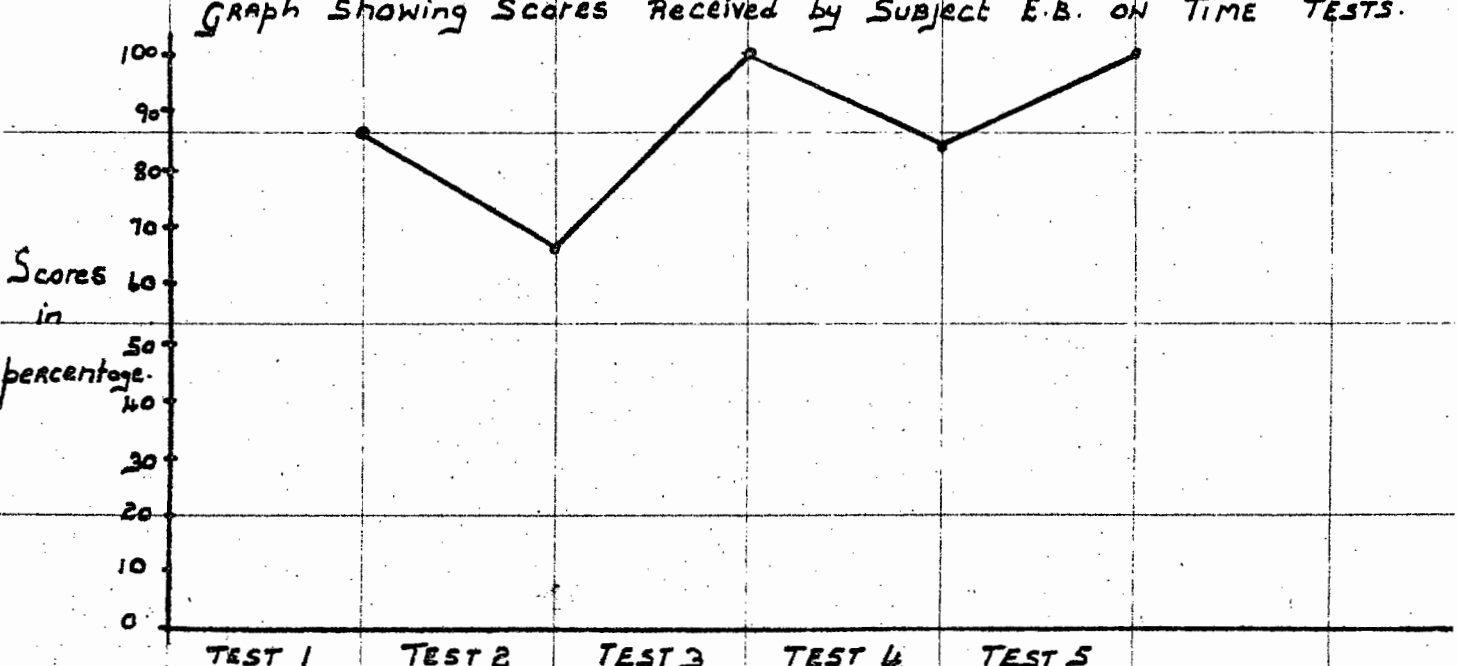
Graph Showing Scores received by Subject E.B. on Number Tests



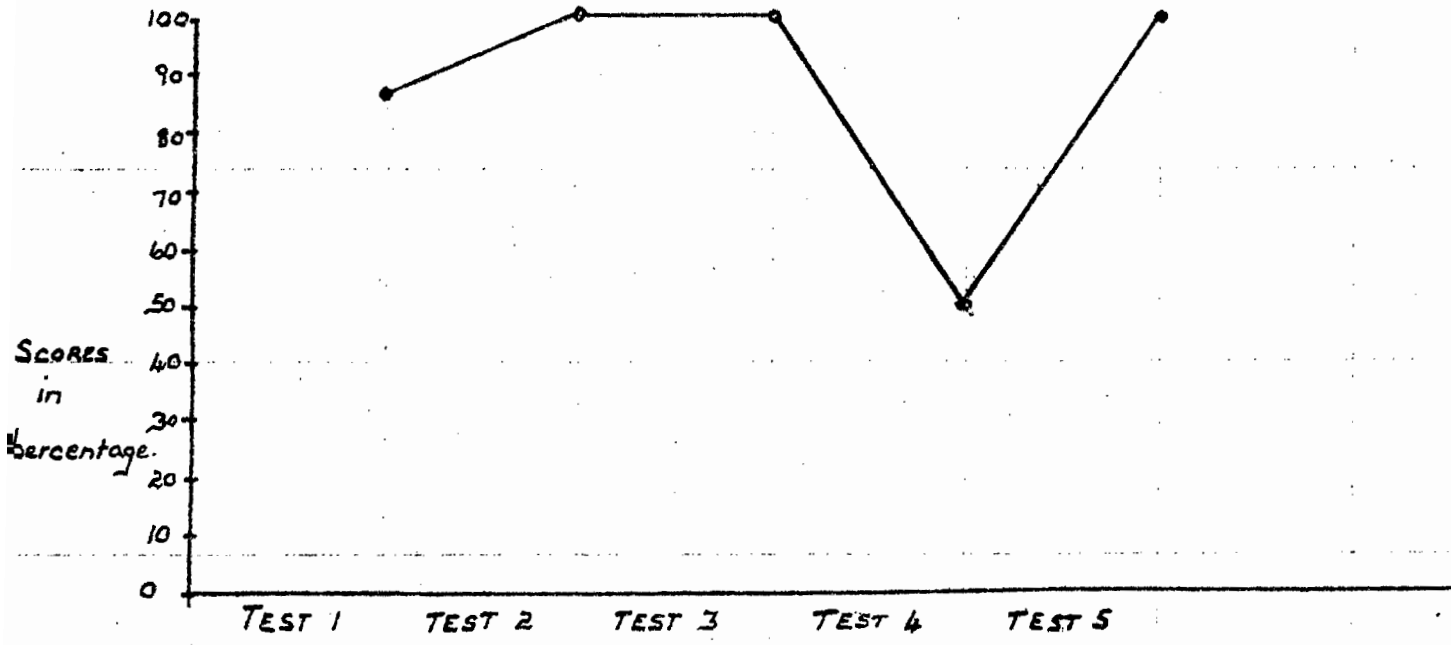
Graph Showing Scores Received By Subject E.B. on Space Tests



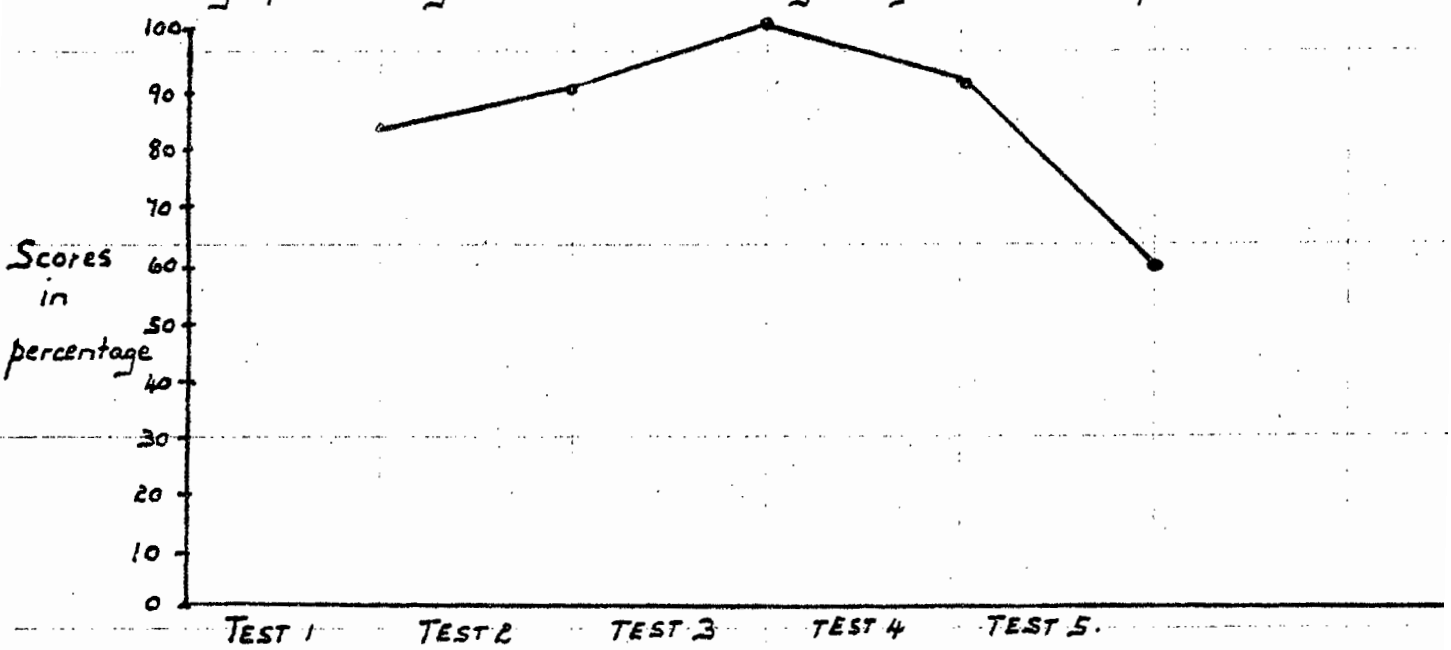
Graph Showing Scores Received by Subject E.B. on Time Tests.



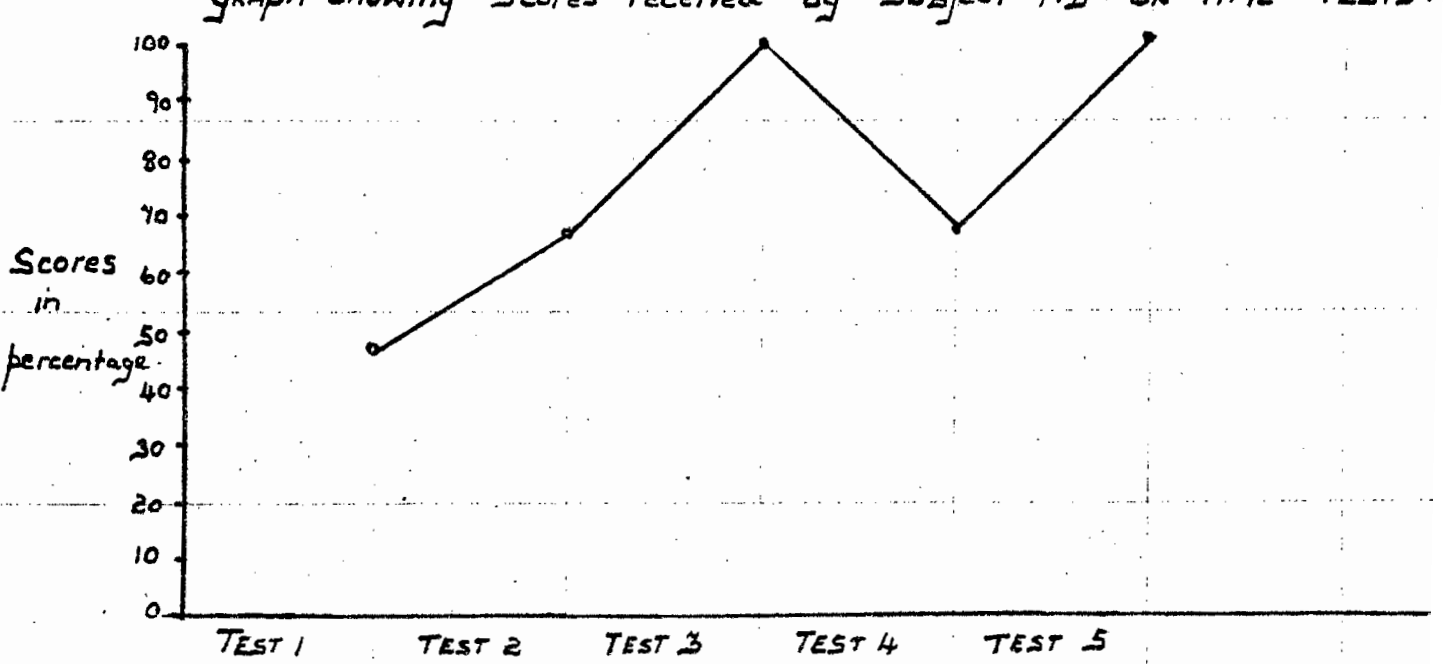
Graph showing scores obtained by Subject F.D. on Number tests



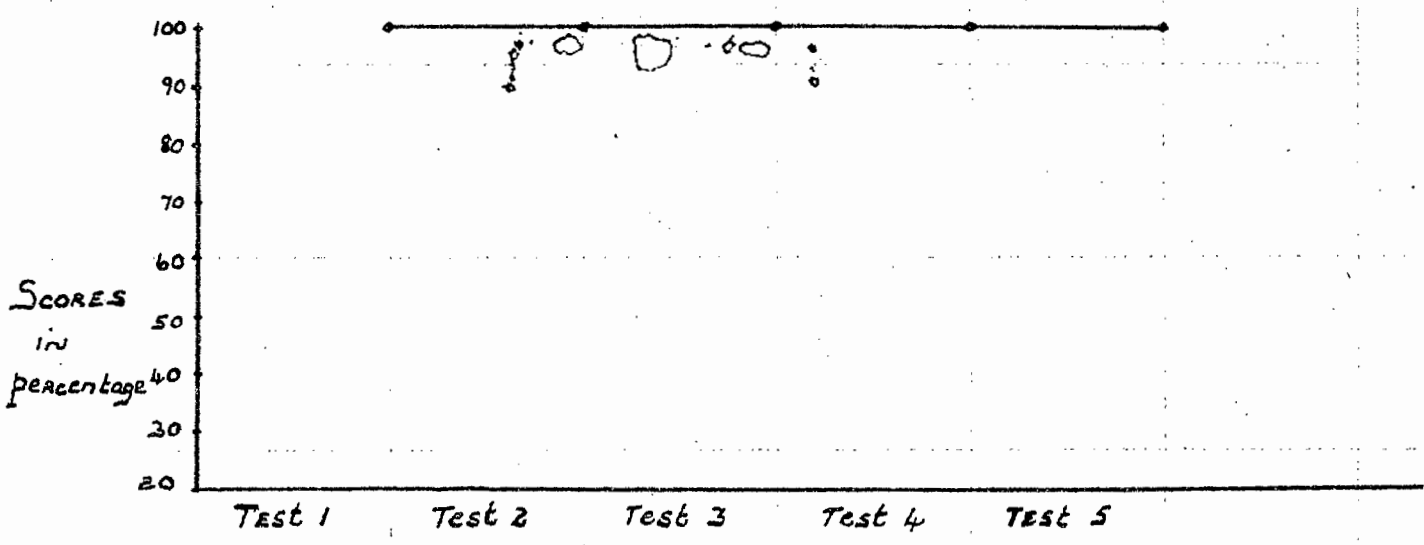
Graph showing Scores obtained by Subject F.D. on Space tests.



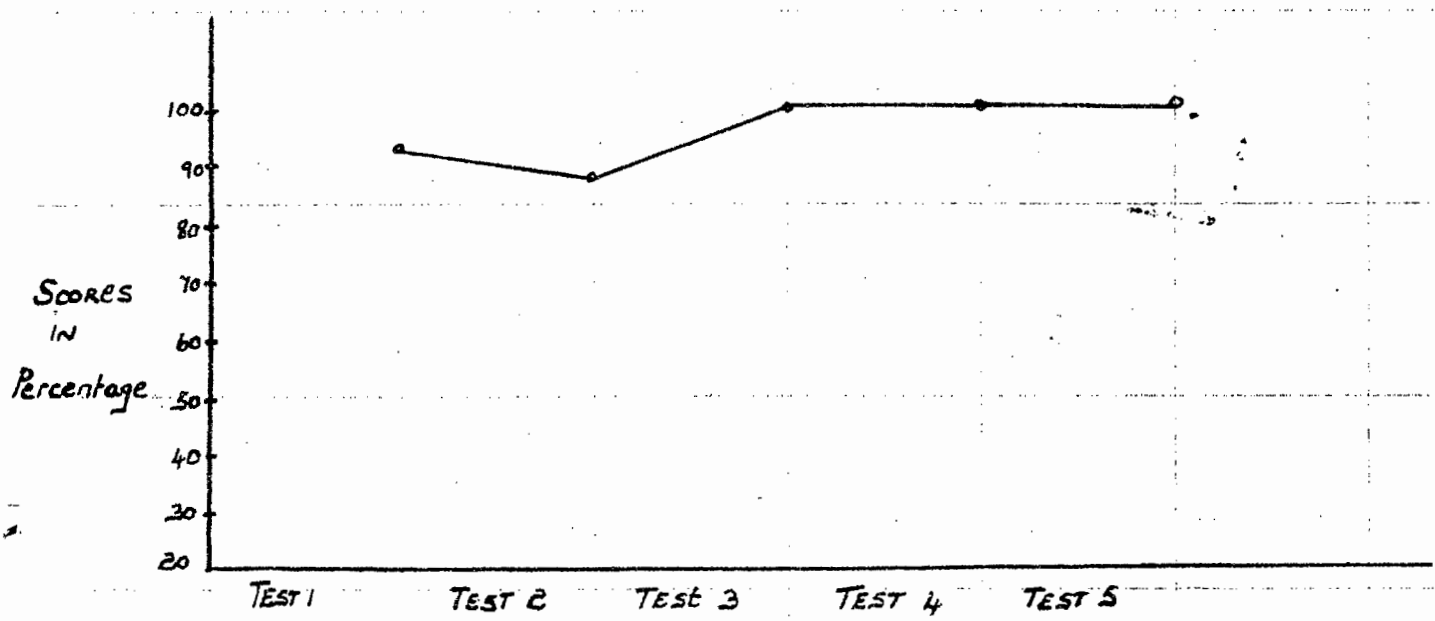
Graph showing Scores received by Subject F.D. on Time tests.



Graph Showing Scores obtained by Subject L.L. on Number Tests.



Graph Showing Scores obtained by Subject L.L. on Space Tests.



Graph Showing Scores obtained by Subject L.L. on Time Tests.