B I B L I O G R A P H Y.

J. G. TAYLOR - The Behavioural Basis of Perception.

HULL - The Principles of Behaviour.

STRATTON - Vision without Inversion of Retinal Image.

MONOGRAPHY by EWERT.

AN INVESTIGATION INTO THE EFFECTS OF DIFFERENTIAL CONDITIONING TO UP-DOWN REVERSAL OF THE VISUAL FIELD

By L. RAKOFF, B.A.

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AN INVESTIGATION INTO THE EFFECTS OF DIFFERENTIAL CONDITIONING TO UP-DOWN REVERSAL OF THE VISUAL FIELD

I N T R O D U C T I O N

It has been stated by Mr. J. G. Taylor[i] of the University of Cape Town that the acquisition of perception is an increasing function of habit strength and subject to the laws of learning as expounded by Hull.[ii] Thus we may regard perception as being functionally dependent on the acquisition of learned behaviour.

The numerous experiments of Drs. Kohler and Erisman at the University of Innsbruck, the wearing of inverting lenses by Stratton as far back as the last century and also the investigations of Ewert and Young - the latter having carried out an experiment with a pseudophone, have given proof to the supposition that

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(i) The Behavioural Basis of Perception - J.G. Taylor.

(ii) The Principles of Behaviour - Hull.

visual perception is the outcome of learned behaviour.

Thus, although no exact scale has been constructed for measuring the strength of the perceptual response to visual stimulation, the evidence strongly suggests that it conforms to the [i] laws of habit strength summation, stimulus generalisation, and afferent neural interaction, and there is evidence that it is increased by reinforcement, just like any other motor or glandular habit. Therefore, on the basis of the results obtained by these experiments, it would seem that perception is somehow a secondary development of overt behaviour.

However, in all these experiments where inverting lenses were worn, they were worn continuously for periods ranging from a few days to a few weeks. The subjects were careful to avoid any periods of normal perception without the glasses, during the duration of their experiments.

It follows, however, from the theory of perception that even if inverting spectacles were only worn continually over a longer period of time the transformation

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[i] Principles of Behaviour - Hull.

from inverted to erect visual perception should nevertheless occur. Because on the basis of the laws of learning, new habits are built up in response to new stimuli, not in response to old stimuli. New responses are built up as a result of disruption of the visual field in certain circumstances, namely, the wearing of inverting spectacles.

HYPOTHESIS.

> My hypothesis is, that by means of differential training in response to inverted retinal stimulation, erect perception of the visual field would be achieved.

If retinal field were to be inverted by a system of prisms so that objects formerly in the upper field of view appear in the lower field and those formerly to the right appear to the left when looking down, old localising habits would be broken down. Retinal inversion will remove the object seen to a new point, thus destroying the normal co-ordination between vision and touch. A new set of retinal-motor habits will thus have to be established which will co-ordinate anew these

various receptors.

In order to test this hypothesis, I carried out an experiment in which I was both experimenter and subject.

For a period of eight weeks I wore reversing spectacles for an average of four hours a day, every day. Wherever possible I tried not to let the wearing of the spectacles disrupt my ordinary daily routine.

For one week prior to the experiment, I wore an apparatus which consisted in a mirror strapped to my head, and my eyes were protected from any direct visual stimulation by means of goggles which covered them, so that I had to look upwards into the mirror in order to see anything at all.

In spite of the fact that this apparatus was found to be cumbersome, so that I had to discontinue wearing it, a certain amount of adaptation did take place. Thus I have included references to this in my report of the first stages of the experiment, where I felt that such information was relevant or had any bearing on my experiences.

APPARATUS.

The apparatus worn for eight weeks consisted in two right-angled prisms arranged so as to produce total reflection, the result being the reversal of the visual field in a vertical plain. The system of prisms was mounted in a rigid aluminium frame fitted with elastic bands which supported it around the back of the head.

The apparatus was surrounded by a mask of black opaque cloth stitched to the spectacle frame.

Dr. Kohler found at Innsbruck that the course of the experiments fell roughly into three different stages:-

FIRST STAGE - In which vision is continuously inverted and movements consistently misdirected.

SECOND STAGE - Movements no longer misdirected and fairly smooth but vision still inverted with occasional correct perceptions.

THIRD STAGE - Continuous erect vision.

My experiences verified the fact that the process of learning to see correctly was divided into three such stages and accordingly I have set out my experiences under these three headings.

As a result of the failure of Ewert's subjects to perceive correctly because of their having worn their apparatus in purely laboratory experimental situations, I avoided their errors because of the realisation that active adaptation to the situation is more likely to produce perceptual results than mere exposure to stimulation. Thus the emphasis is on active behaviour whenever wearing the spectacles.

It will be noticed that in many cases there is a certain degree of overlap. This is only to be expected as it is impossible for all habits to be at the same stage of development at exactly the same time.

FIRST STAGE

S T A G E I - ABOUT 2½ WEEKS

I wore the glasses at the university occasionally but most of the time in my own home and around my neighbourhood where I found it easier to set myself practical tasks to carry out.

Within the three different stages I have attempted to record my experiences under different headings. These headings are merely used as a general means of differentiation for purposes of convenience. Thus they are not intended to be specific and a great deal of overlapping will be noticed.

GENERAL IMPRESSION OF VISUAL FIELD AS A WHOLE.

When I put the glasses on my first reaction was a feeling of unreality. As I looked around me, the visual field was not immediately clear but after a few moments this sensation disappeared and I saw the room distinctly. I realised, however, that my range of vision was somewhat narrower than it was normally, thus I was not able to see as much of the room at one glance as I could without the spectacles.

This awareness of the narrowing of my range of vision was accompanied by a sensation of instability. The whole visual field swung before my eyes, very much the way the landscape does when viewing it from an aeroplane which is coming down to land.

For the first few moments this swinging and swaying of the room in front of my eyes was so marked that the inverted position of the objects and the people in the room was of secondary importance.

This swinging of the visual field persisted until fairly well on into the second stage of the experiment, though to a much smaller extent. At the very beginning, even if I kept my head perfectly still, the visual field was still swinging. Later on the swinging was only noticeable when my head was moving and not otherwise. For instance, when I looked through the window I was unable to see anything at all because of this continuous oscillating movement of the whole landscape.

Then, besides the fact that everything was upside down, I had to contend with this continuous fluctuation of the visual field which made the fixating of any particular point extremely difficult. The places I went into all seemed unfamiliar although I knew that they were

not unknown to me.

Although the visual field was narrower than it normally is, the extremities of the room seemed to be further away than I actually knew them to be situated. This was no doubt due to the type of prisms which were used for the apparatus. Later on I found that the corridors appeared to be much longer, the street and even the relative distance of individual objects seemed exaggerated.

Thus the general characteristic was a decrease in the extent of the visual field and the specific characteristic was an increase in the relative distances of objects. For instance, when looking down the street, I could see to the first corner, whereas normally I could see much further down, but the corner seemed very much further than I knew it was.

REACTIONS TO OBJECTS AND PEOPLE WITHIN THE VISUAL FIELD.

The most obviously inverted image which confronted me was the human body. Throughout the stage of inversion the human body, especially from the waist down, was so clearly walking around on its head that on occasions

when I forgot that I was wearing the glasses, I found myself thinking "What is wrong with them?" It may be noticed here that my reaction was not one of something being wrong with me, but with the people and also the objects I was perceiving.

There was a marked sensation of incongruity throughout. This arose because of the conflict between my knowledge of what a particular object was and how I actually perceived that object. Thus I had constantly to differentiate between the new appearance of the object and the former appearance of it.

I would like to point out that although in the first few days I used sub-vocal language to tell myself how to make the correct movements, I tried not to rely on such methods of training. In any case it will be noted further on that even this did not make any difference once the correct movements in response to stimuli had been firmly established.

Each object I perceived I examined closely before I attempted to do anything with it. As, for instance, when I tried to open a door, I first tried to make sure that I knew exactly where the door-handle was, and in spite of that my hand went up above the handle and I fumbled around until eventually I brought it down because I was told that my hand was too high above the

actual handle. This sort of incident was very common during this stage and characterised by a sort of semi-circular hand movement.

I was still able to recognise people and objects for who and what they were. I felt rather uncomfortable, though, talking to people because I seemed to be concentrating on the sound of their voices, not on actually observing them. I seemed to hear their voices first and then look for them in the direction from which the sounds were coming.

GENERAL SITUATIONS IN WHICH I WORE THE SPECTACLES.

As I have stated before, I wore the spectacles mostly around my own house where it was less of a risk trying to do the things I wanted to do.

Each day before putting the spectacles on I decided on a 'line of activity' for the following few hours.

I usually ate my meals while the spectacles were on and tried to serve the food at the table; I went for walks round the neighbourhood and at this stage was always accompanied by someone and even managed to cross the streets uneventfully; wrote on almost every occasion; tried to read but found throughout that I could only decipher the large headlines in the newspaper; attempted

to cut out an article of clothing using a paper pattern; had artificial obstacles set out for me in the house and invariably bumped into them if they were on the floor.

I also did such things as wash the dishes, tidy drawers and put articles away where they belonged; watered the plants; tried to light innumerable cigarettes; tried to play with a tennis ball. Thus it will be seen that I tried not to be idle at any time while wearing the spectacles.

LEFT - RIGHT REVERSAL.

It should be noted at this point that although the visual field is reversed in the up-down sphere when looking directly at any object, when looking down on to any object there is a left-right reversal: for example, when looking down at my feet, I saw them the right way up, but when asked to indicate the right foot I invariably pointed to the left foot and vice versa. For instance, walking along an S-shaped line was quite impossible at this stage, because besides the fact that I kept going away from the line instead of towards it, my sense of balance was very much upset by this sort of activity.

Thus there were two sets of habits which were being disturbed, though the effects of both were not experienced simultaneously. This necessitated two new patterns of behaviour being acquired in response to two new sets of stimuli. However, the up-down disturbance still remained the most dominant one in general. In specific instances, such as looking down at objects, it was not obvious that there was anything incorrect in my perception of them until I actually had to make physical contact with any one of them. When, for instance, I tried to take the teaspoon from the saucer, I put my hand on the far side of the cup, when the spoon was actually on the near side.

This left-right displacement was due to the prisms being total reflecting ones, so that looking down on to objects creates a mirror-wise effect.

The reconstruction of the right-left relationships proceeded at a greater speed than the up-down, in that my movements were far more quickly adapted to these particular new stimuli. After a few days of the experiment I could quite easily pour the tea from the tea-pot into the cup, whereas before I had poured it down the side of the cup.

MOVEMENTS.

Reaching Movements.

When I first reached out to try and touch someone else's hand, my movements were inevitably too high above the other person. The effect was that I stretched out my hand and it came short of the object I was trying to contact, but realising, because of the reversal of the visual field I must bring my hand down instead of moving it up, I told myself this and eventually arrived at my goal. I arrived at my goal not because I had told myself what movement to make to realise it but mainly because of numerous trial and error movements and it was inevitable that one of them should make contact with the object. I had adopted a semi-circular arm movement in order to reach the object.

This sort of movement had been noticed before while I was wearing the mirror apparatus and my attention had been drawn to it and I had tried to correct it by making a straight downward movement directly towards the object. However, the initial upward movement was difficult to eliminate and it persisted in numerous instances. Thus a certain degree of transfer of adaptation to stimuli from the wearing of the mirror apparatus had taken place.

Here again, there were marked feelings of incongruity because of the conflict between knowing where the object was and feeling and seeing it in a different place. It made me feel at times as though there were two hands, one where I saw it, and the other where I felt it. For instance, I held a long ruler in my right hand and with my left hand I tried to grasp the end of the ruler but I was quite unable to do so. I could see where my right hand was and I could feel it, and yet when I tried to bring my left hand to grasp the object from out my right hand I failed to do so. It was therefore necessary for me to virtually explore my right hand before I was eventually able to grasp the object.

On the other hand, reaching for objects at the table during meal-time was a much simpler task because here it was easier to resort to tactile stimulation as a means of arriving at the desired object.

Reaching out to catch a ball was also an impossible task at this stage because the ball, immediately it was thrown at me, disappeared from the visual field completely. Although I knew where it was likely to land, I was unable to follow its path of movement.

What has happened here is that the ball which was in the periphery of the visual field evoked a head movement which would normally have brought the ball into the centre of the visual field. Because the ball is actually in the upper part of the visual field but has appeared in the lower part, the head automatically turned in that direction, the result being that instead of the ball coming into the centre of the visual field it passed out of it altogether.

Movements directed at switching on the lights, opening the door and taking objects out of people's hands, were only successful after a number of attempts. Then, also, when trying to light a cigarette for someone else, my movements were unsuccessful. The initial movement went in the right direction but always ended below the actual stimulus object and thus failed.

It has been illustrated here that visual behaviour did not co-operate successfully with other senses. For instance, when grasping an object, the object and hand were visually localised in one position but tactilely localised in another position.

Thus it could already be observed that there was a disruption between the present visual behaviour and the

old spatial habits. Adaptive responses were invariably incorrect when guided by vision and a process of trial and error exploration was necessary to discover the actual location of the object.

Reaching movements initiated by retinal stimulation were likely to be misdirected. (I had a better chance of reaching my specific goal if I shut my eyes and relied on tactile stimulation to get me there. I refrained from doing this, as obviously I would have defeated the aim of the experiment.)

To sum up, then, the customary correlation between movements initiated visually and my knowledge of the positions of the objects towards which the movement was directed, had been broken down.

Walking Movements.

The feeling of experiencing inharmonious perception was very marked while walking. For instance, trying to find my feet was a peculiar experience. When I looked down at them they seemed to be further away than I knew them to be. At first, when trying to walk up and down steps, it was necessary for me to establish myself firmly at the edge of the steps and feel where

they were before I could proceed up or down them. However, I soon acquired the ability to walk up the steps unhesitantly. This was most probably due to the strength of tactile stimulation. It was easier to walk up and down the steps by merely feeling my way than by looking at them, and if I did the latter I inevitably felt giddy and had to stop.

Force of gravity is important here, too, because I found that if I walked carrying a heavy weight in my hand, my sense of balance remained undisturbed. Thus, force of gravity in this particular kind of situation was dominant.

When walking in the street I tended to try and avoid bumping into obstacles which appeared to be in my path, in spite of the fact that I knew I was merely perceiving them there. The tops of the trees appeared to be in front of me, so that I would walk around them to avoid bumping into them.

I was able to walk in an apparently steady manner but I did not feel secure as the visual field bobbed up and down incessantly as I walked. I avoided bumping into people, though, by starting to get out of their way long before they were near me. In reality, I think, they were careful to avoid getting too near to me.

I felt my way around corners. The cars travelling along on their bonnets were quite an amusing sight, but trying to get into a car which was standing on its bonnet was anything but amusing. I was unable to find the door-handle until someone guided my hand to it.

To sum up here, then, it is obvious that normal walking movements were less affected by inverted retinal stimulation than other movements such as reaching and grasping movements. This is no doubt due to the reliance of foot movements on tactile stimulation, as in any case most foot activity takes place outside the field of view, or within indirect vision.

Avoidance Movements.

On the other hand, correct avoidance movements were not so quickly acquired. For instance, when a set of obstacles was put on the floor in the house, and I tried to avoid walking into them, I did try and step over them but usually found that I had done this in a spot where there was no actual obstacle.

Fixation Movements.

I should reiterate here that the whole visual field appears to swing in front of one, moving through space in the same direction as the movement of the head but at twice the speed. Thus fixation, especially of near objects, was extremely difficult in the beginning.

It always took me a few moments before I could fixate any point at all. Numerous head movements were necessary before I could, for instance, bring any face directly and clearly into my line of vision. I also found it more difficult to converge on near objects than on far objects. In fact, when someone held out a cigarette quite close to me, I saw two cigarettes in the person's hand for a few seconds. Thus, head and eye movements became exaggerated. This is only to be expected as head and eye movements have to be reversed and before they could be firmly established in reverse, numerous trial and error movements would have to be executed.

The unusual strain of attention and the difficulty of finally getting any movement to its goal made all movements extremely tiring, especially after I had

already been wearing the glasses for a few hours. Relief was sometimes obtained by relying entirely on tactile stimulation but I tried to avoid having to do that.

Head and eye movements have to be reversed but the eyes still move normally in the head. The eye can scan the image without producing any obvious disruption in behaviour. However, the apparatus was strapped to the head in such a way as to move with every movement of the head.

Thus the disruption in behaviour arises from the gross fixation movements in dividing head and body movements which result in the stimulus object which arouses such movements moving further towards the periphery instead of to the fovea and the movements therefore have to begin again. What had happened was that the actual visual field was now being taken by itself and not supplemented as normally by a system of objects gathered and held from preceding visual experience.

Movements of Objects and Body.

Together with the exaggerated head movements which were described before, there were also exaggerated movements of objects in the visual field. Even if I kept my head perfectly still, objects still seemed to be slightly moving, until I established physical contact with them. As soon as I touched the object, it usually stopped bobbing. For instance, this was very marked when a cigarette held in someone else's hand seemed to be moving up and down but when I took it in my own hand it appeared to be perfectly static.

This only occurred in the very early stages of the experiment but can be explained by the presence of another reference frame, namely a tactile one, so that in this particular instance the tactile stimulus (that is, of feeling the object as being quite still) was stronger than the visual stimulus of seeing it moving and the response was consequently made to the tactile stimulus.

When driving in a car, the effect of surveying the scenery was similar to seeing a rapid succession of photographs, all upside down, sometimes going past so quickly that I was unable to make out anything at all.

This was no doubt due to the fact that the car was going so quickly that there was no chance for the head and eyes to make any adjustments at all to the changed landscape.

Trying to follow the movement of an object with my own hand was unsuccessful, especially if the object was being moved at a high speed. For instance, when a friend held her hand out and moved it, upwards that is, the direction of the movement appeared to be a downwards one. I moved my hand downwards trying to follow it, and then her hand disappeared completely from the visual field.

Then realising what had actually occurred, I told myself to move my hand downwards, when hers appeared to go upwards and vice versa, so that the movements became correct. If, however, the rate of the other person's movements increased to such an extent that I did not have a sufficiently long interval of time, in which to tell myself in what direction to move, the consequent movement was misdirected.

Thus, when the movement was correct, at this stage, I was responding to a verbal stimulus and not a visual one. When a response was made entirely dependent on the visual stimulus, it was invariably incorrect.

TILTING.

The visual field appeared to be swinging in front of my eyes all the time, but when I tilted my head the visual field appeared to swing even more. Let me clarify what happened by quoting an example:-

In my room I fixated the vertical outline of my window. I then rotated my head to the right, all the time following the vertical line until it appeared to be in a horizontal position, so that the book-case which in actual fact was to the right of the vertical line now appeared to be alongside the horizontal line. The actual movement of the visual field here appeared to be a rapid one. Yet when asked how far I had tilted my head, I replied that it felt as though I had tilted my head through an angle of 90^{o}, i.e. it appeared to me that I had tilted my head through the same size angle as the actual visual field had tilted. But when asked by an observer, I was informed that I had only swung my head through an angle of 45^{o}.

This I was able to verify for myself by carrying out the same procedure, but using a ruler instead and in front of the mirror trying not to look at the mirror until the necessary head and eye movements were concluded.

I repeated this type of activity throughout the experiment and later on will refer to a slight variation which was noticed in my reactions to this tilting. I spent a short period each day drawing horizontal and vertical lines with my head tilted at appropriate angles, relative to the lines. The angles I drew at this stage were all rather bigger than I intended them to be.

What happens then is that the visual field appears to swing in the same direction as the head but at twice the speed, as illustrated before, and therefore through twice the angle in the same period of time. At times the effect is similar to that of watching an early 20th Century film, with its continuous jerky movements, and throughout this stage of the experiment I was aware of an atmosphere of unreality about the visual scene as a whole but not so marked when perceiving individual objects.

VISUAL AND TACTILE STIMULATION.

It was becoming obvious, even at this early stage of the experiment, what an important part tactile stimulation plays in learning how "to see". It was also clear that in spite of the fact that visual perception

was obviously disturbed by the reversal of the visual field, some older habit structures are so strong that the old tactile stimulus would spontaneously evoke the old visual response. Thus where the tactile stimulus was dominant, correct perception was the consequence. The dominant reference frame is then a tactile one and not the visual one. I shall illustrate this by reference to a few instances:-

Someone was carrying a vase and I looked at it rather intently because it looked extremely peculiar; I then took the vase from the person and held it in my own hand. The vase was an extremely heavy object, which in itself had a positive effect in that the weight of the vase rested on my hand, and I could feel that it was the flat base on my hand; with my other hand I held the top open part of the vase in order to support it and I then perceived the vase the right way up.

I was holding the vase fairly high up so that it could not be said that I was looking down on to it, and that was the cause of my seeing it the right way round. It was the strong tactile stimulus together with my knowledge of the flat base of the base being the bottom of the object and the wide open part being the top of it,

which made me perceive it the right way round.

It is then one's particular behaviour towards individual objects in certain situations which at times is the dominating force and determines one's perception of that object.

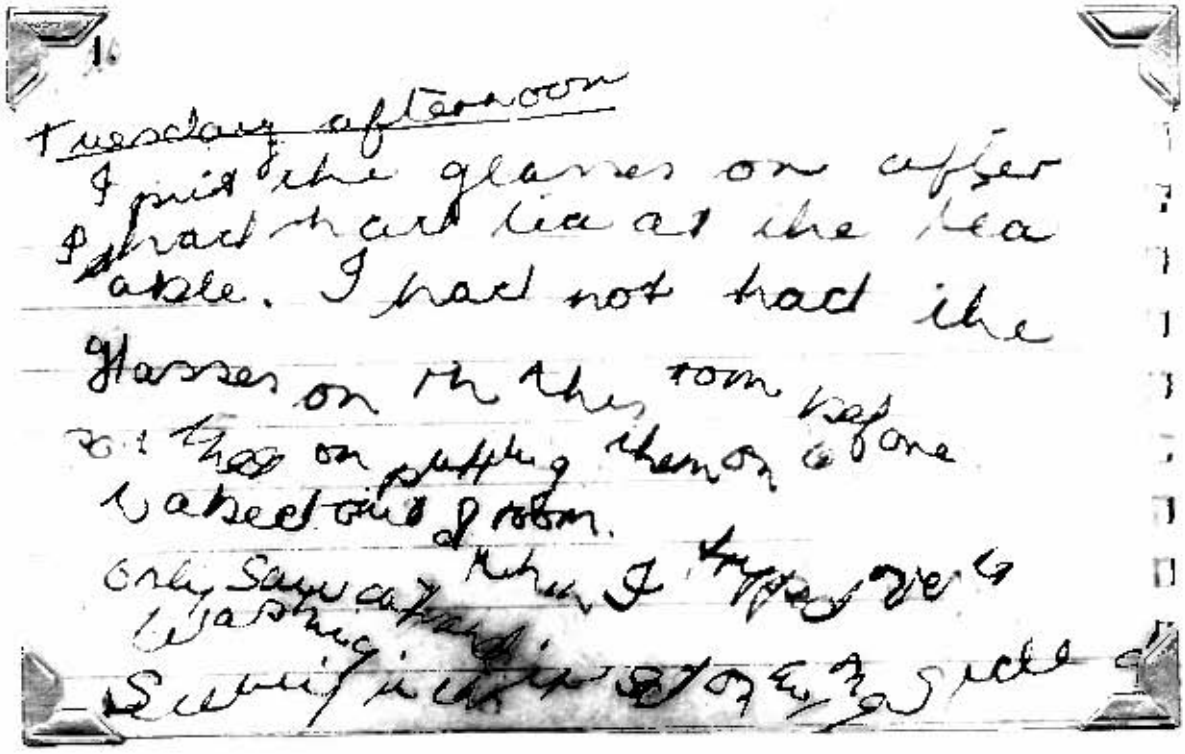
There were a few more examples of this type of response during the early part of the experiment. For instance, after wearing the glasses only a few times, every time I took a cigarette in my hand, examined it with my other hand so as to get the filter end going in the right direction towards my mouth, I saw the cigarette with the filter going in the right direction. I knew it was pointing the right way because I could feel which way it was pointing. In someone else's hand I invariably reported the cigarette as going in a direction opposite to the one in which it was really pointing.

These above-mentioned situations were all instances in which the reference frame was a tactile one, but there were numerous situations where the visual and tactile stimuli both seemed to be of the same strength, so that the result was a complete lack of harmony between visual perception and tactile sensation.

For instance, when I washed my hands under the tap, my hands seemed to be so much further away from me than I felt they were, and also much deeper down in the wash-basin than I actually knew them to be. The feeling of incongruity was also exceptionally marked when I stretched out my hands to touch the back of someone's head and kept touching her face instead. I was quite convinced that I was making for the back of her head, but my point of contact was in actual fact her chin. Thus, I kept having the sensation that there were two separate worlds, the one in which I felt things according to the old system of habits, and one in which I perceived things in response to a new system of stimuli. It was beginning to be extremely confusing.

WRITING.

Each day while wearing the glasses I did a little writing and below I have included a sample of writing during the first stages of the experiment.



The example shown here is not a sample of what was written on two occasions, but on one. It will be noticed that the first 3 lines look quite normal but after that everything appears rather confusing. What

had probably happened was that when beginning to write the old system of habits was evoked and thus I was able to write correctly, but as I continued the new system of stimuli appropriate to the altered pattern of retinal stimulation began to take control and the ensuing conflict gives rise to a state of confusion.

New responses are attached to the altered stimulation and the same applies to proprioceptive stimuli but the latter apparently take a longer time to adjust to the altered pattern of stimulation so that relying on the old proprioceptive stimuli kept me going in the right direction for a little while. In other words, the result was the same as though I had kept my eyes closed while writing these first few lines. But as soon as I began to rely on the altered pattern of visual stimulation, the result was confusion.

The initial movement was started without the aid of vision but the final adjustment is guided by vision. Thus a movement starting from a position not necessarily affected by the appearance of the visual field at the moment but directed to what happens to be in the visual field was liable to be interrupted before the final goal was reached and to end in a series of fumbling and apparently undirected movements. The movements are very like

those which occur when one is trying to trace the outline of an object, only the reflection of which is visible in a mirror.

An interesting phenomenon was noted in connection with writing. Most of the time my writing was cursive, but occasionally I deviated and wrote numbers, and also Hebrew. Now, in writing in Hebrew and writing the numbers I appeared to be able to keep all the letters in a more reasonably straight direction than when writing cursive script. This was also still in these early stages of the experiment.

Now, in learning to write correctly a much larger range of habits have to be acquired than in response to the other ordinary stimuli. A new pattern of responses has to be acquired for each word and one has to learn to discriminate between individual words. However, when writing Hebrew and numbers, each character is written separately. This means that the pen has to be lifted between each character and thus there is a separate interval of trial and error between each symbol enabling one to find the correct position of each separate character. Thus it follows that there should be more correct behaviour when employing this type of script than when using cursive script.

Writing on the whole was difficult at this stage

because of the necessity of keeping quite far away from the paper, as otherwise I could not bring the part of the page I was writing on into the centre of my visual field.

RESPONSES TO AUDITORY STIMULATION.

Responses to auditory stimulation were at times slightly affected by the altered visual stimulation. The effect was only noticed when a response was made purely to an auditory stimulus. For instance, if I heard a sudden noise and turned towards the direction from which it came, I sometimes could not perceive the object from which the stimulus was coming at all. An example of this was when I heard the cat mewing somewhere on the left of me, I turned in that direction but was unable to find the cat there. When eventually I did find the cat by looking to the right and I watched while it mewed, there appeared to be no incongruity between auditory perception and visual perception, whereas there had been before.

This occurred only rarely, and it was only during this one incident that I noticed any sound disturbance. I therefore feel quite sure in saying that in this par-

ticular experiment, sound localisation played a very insignificant part in the learning process, and it is only to be expected that this would be the case in the up-down reversed situation.

PHYSICAL, ORGANIC REACTIONS.

During the wearing of the spectacles there were exaggerated movements of objects during movements of body and head which were also exaggerated, resulting in feelings of giddiness and nausea. I was also inclined to feel rather fatigued after having had the spectacles on for an hour or more. My eyes especially would begin to feel strained. A sensation of insecurity prevailed throughout the beginning, but began to disappear towards the end of this stage.

The whole system of behaviour has been disrupted. This does not only signify that external behaviour patterns have been disturbed but also that a certain degree of internal conditioning has also been effected. Thus new internal behaviour patterns have also to be built up. During this process, before the new internal habits have been firmly established, there were feelings of nausea but no actual vomiting.

EFFECTS AFTER REMOVING THE APPARATUS.

The immediate effect after removing the spectacles, at this stage, was that it was much worse with them off than with them on because the visual field appeared to be upside down as well as intensely blurred. The visual field righted itself after a few moments, but the blurring continued for an average of two hours to one hour. My eyes also felt strained and tired but that disappeared when the blurring disappeared. It was still difficult to fixate any object for any length of time and I seemed to be making far more head and body movements than were necessary. An acute awareness of the movements (many of which were incorrect) I was making also accompanied this removal of the spectacles.

Thus, when spectacles were removed, the newly acquired spatial habits persisted to the extent that adaptive movements to objects were also wrong when guided by visual stimulation.

SUMMARY OF FIRST STAGE.

In moving about in space physical requirements are satisfied by means of adjustment to physical patterns of environment. The altered pattern of retinal stimulation had the effect that many actions failed to satisfy my needs. This did not mean that my needs went completely unsatisfied, but had to be satisfied by other actions in response to stimuli not affected by the altered pattern of retinal stimulation.

(1) Movements initiated by retinal stimulation were no longer precisely adapted to the position of objects within the visual field and were thus bound to be extinguished. Thus, during the first stage of the experiment, a gradual process of extinction was set in motion.

(2) When responding to visual cues adaptive movements were invariably incorrect but responses to tactile stimuli were successful when vision was excluded. Responses to auditory stimulation were generally correct, whether it was presented simultaneously with visual stimulation or not.

(3) There was no immediate reconstruction of the new visual orientation to agree with the orientation of other senses such as touch.

(4) The inverted retinal stimulation is not necessarily always the dominant stimulus. When tactile stimulation and force of gravity are dominant, you may have correct perception, even at this stage.

SECOND STAGE

S T A G E II - ABOUT 4½ WEEKS.

The spectacles were worn for the most part in my own home and around the neighbourhood. During this time numerous walks were taken near my house and to the park.

GENERAL IMPRESSION OF THE VISUAL FIELD AS A WHOLE.

The narrowing of the visual field which was so prevalent at the beginning of the experiment no longer hampered me. Although the range of vision according to the structure of the apparatus was still exactly as narrow as it was originally, I was no longer consciously troubled by the fact. Also, the visual field had stopped swinging and swaying in front of me as much as before.

What had probably brought this about was that such exaggerated head and eye movements were no longer necessary in order to fixate any particular part of the visual field and that I had by then learned how to

survey the visual field in general with the minimum of head and eye movements necessary in order to perceive the maximum limits of the field. So that when coming into a room I could see the whole room at a glance without having to carry out the numerous head and eye movements which were essential before.

However, with the movement of the head there was still a slight swaying of the visual field, though it was no longer troublesome and only discernible when I moved my head quickly, from one position to another.

The apparent increase in the relative distances of objects had also ceased to be a hindrance. I had apparently learned to perceive objects in their correct positions in space, although still not in erect positions. Thus, a fair amount of perceptual adaptation had already taken place as a result of learning. Because I had, by trial and error, discovered that objects were in reality nearer than they appeared to be; because, for instance, I reached the corner of the street sooner than I should have, judging by what my visual perception had told me, I eventually learned to find objects and such things as street corners, in their exact situation in space, although still reversed.

In spite of the fact that this whole stage was characterised by the execution of correct motor responses to stimuli, there was still a sensation of incongruity prevailing whenever I wore the glasses, but not one of instability.

REACTIONS TO OBJECTS AND PEOPLE, WITHIN THE VISUAL FIELD.

The incongruity between the world as I knew it without the spectacles and the world as I saw it with the spectacles on, still persisted. However, I no longer used sub-vocal stimulation in order to tell myself what to do; in fact, I stopped thinking that objects and people were upside down. When, for instance, I looked at the windows and the doors they were just windows and doors. My response was no longer in the form of the thought, "Those are windows and a door the wrong way round", but merely, "Those are windows and a door."

People still remained the most obviously upside down objects I had to contend with, though I noticed that I was no longer concentrating on the sound of their voices as I had done earlier on in the experiment.

It is interesting to note that I had little difficulty in performing correct movements and arriving directly at my goal in most cases, but nevertheless the feeling of incongruity persisted. I did not, however, feel as though my sense of balance had been disturbed.

I had, however, begun to react to objects and people spontaneously: that is, without the detailed examination of objects which I undertook in the first stages of the experiment, before acting in any way towards them. I was now more aware of the general characteristics of the visual field as a whole, rather than the specific nature of the objects in the field.

GENERAL SITUATIONS IN WHICH I WORE THE SPECTACLES.

The situations were mainly the same as for the beginning of the experiment, except that I wrote more and walked about more than during that stage. I spent quite a bit of time in the park playing with the dog and trying to dodge away from him (and providing an endless source of amusement for the other visitors there). Then I did the usual sort of things about the house; helped in the kitchen and sewed and knitted and had my meals with the

glasses on. While doing all these things and numerous other little tasks which I set myself in and around the house, I insisted on being unaccompanied. I felt rather wary of crossing the street by myself at first and a slight uneasiness about that persisted right until the end of the experiment.

LEFT - RIGHT REVERSAL.

The correct movements in response to the reversed left-right relationship were firmly established during this stage. I also seemed to perceive the objects in their correct positions. Unfortunately, I cannot state emphatically that the left-right relationship had completely righted itself perceptually because I did not really know how to report what I saw. Thus the confusion which existed here was verbal in nature rather than motor. Looking down on to objects is a simple enough task, admittedly, but when a new system of habits is being built up while simultaneously an old system is being extinguished there is bound to be a stage of conflict, a stage where the new habits have been built up sufficiently to be at the same strength of development as the old habits which are becoming weak enough to be overruled by the new habits. The

effect of this is then a variation of old and new habits, according to which is strongest at the particular moment under consideration. As the habit strength structures vary from moment to moment, it is not surprising that verbal reactions to these stimuli are somewhat confused.

But I must point out that there appeared to be nothing incongruous about the left-right relationships. The table appeared to be set quite normally and my feet no longer appeared to be in the wrong place, and I was able to follow the S-shaped figure quite easily without upsetting my sense of balance as it did in the earlier stages of the experiment.

I saw the staircase in its correct position and I no longer indicated my left foot after my right foot had been pointed at.

It is apparent from these examples that the learning process proceeds at different rates for different sets of habits. The left-right reversal did not have such an all-round disturbing effect as the up-down reversal; it only applied in a few specific situations. Thus fewer behaviour patterns were disturbed, thus fewer new ones had to be built up again. Therefore it is not that the rate of learning to react to altered retinal stimu-

lation is quicker in the left-right sphere than in the up-down one, but merely that there were a smaller number of new habits to be acquired and fewer old habits to be extinguished.

Other experiments at Innsbruck have shown that the left-right reversal actually takes much longer to correct itself than the up-down reversal.

MOVEMENTS.

Reaching Movements.

The initial upward movement before making direct contact with objects had been successfully eliminated by this time. Thus this habit was quickly extinguished before it was firmly established, by means of conscious training. The transfer of adaptations which had been made from the former experiment had been successfully extinguished. Reaching and grasping movements were then smooth and effective in arriving at their respective goals.

I was now able to follow the movements of a ball effectively so that I was able to catch it, when thrown towards me. Apparently I had learned to make the correct movements in order to maintain the ball in the

centre of the visual field most of the time. Sometimes, however, the ball was inclined to disappear while coming towards me. It appears, then, that although I had learned to make the correct head and eye movements, these new movements were not yet so firmly established that they constantly remained dominant. The old habits were still strong enough in this particular situation to be more readily evoked than the old ones, at certain times.

Activities like opening doors, switching on lights, picking up and grasping objects and doing things in the kitchen, were all done as efficiently as they would normally have been done without the glasses. Reaching movements initiated by retinal stimulation were no longer misdirected.

The incongruity between tactile and visual stimulation, although still present to a slight extent, was not felt as much as in the beginning. I had apparently learned to accept objects and people as being upside down without consciously thinking there was something particularly peculiar about them.

Fixation Movements.

Fixation movements were now also easier to accomplish. Objects seemed to be in the centre of the visual field with little or no difficulty. I no longer felt that I had to "peer" at objects intently before I was able to see them clearly. Convergence on near objects was no longer a conscious effort and exaggerated head and eye movements seemed to have lessened.

I no longer saw double images of familiar objects and could quite easily light someone else's cigarette without singeing that person during the process.

What had happened during the first stage of the experiment was that the failure of the habitual response had been followed by other movements of eyes and head. These movements had followed each other in rapid succession until one of them was bound to result in fixation of the stimulus object or in direct contact with it as in the reaching and grasping movements. Therefore, on repetition of the presentation of the same or similar stimulus patterns, these movements were reinforced. Thus, in the second stage of the experiment there are a whole series of new motor habits established

in response to the altered pattern of retinal stimulation, the motor responses in this case being the response movements of eyes and head. Therefore, by an initial trial and error learning process, I was beginning to acquire the new responses necessary in order to be able to perceive objects as they were, according to the changed retinal stimulus patterns.

Walking Movements.

Although the visual field now tended to remain static when my head was still, while walking outside in the street there still appeared to be a slight bobbing of the visual field. This bobbing of the visual field was not at all visible inside the house and when walking short distances. This is probably explained by reason of the fact that as I spent more time in the house than walking around outside I had more chance of acquiring new patterns of behaviour appropriate to situations inside than those out in the open. New responses had not yet been sufficiently generalised to the extent that they could be applied to all different situations.

I did, however, walk about unaccompanied by any

other person and did not feel insecure at all. Motor vehicles and people still looked peculiar driving and walking along on their bonnets and heads respectively. I no longer found it necessary to feel my way around the corners either; they were now situated where they actually appeared to be. Finding my feet was also no longer a difficult task.

Avoidance Movements.

By this time I had successfully learned to avoid walking over obstacles in a place where they were actually not situated. I avoided objects on the floor without having to say to myself: If I see it there it must be on the other side. While walking, trees and hedges still appeared to be at my feet but I persisted in walking right through them. This sort of situation still left me with marked sensations of incongruity. Avoidance movements, on the whole, therefore, were successfully concluded.

Movements of Objects and Body.

Individual objects no longer appeared to be moving around in their particular positions. Provided that my head kept still the objects themselves remained perfectly static. I was now able to follow the movement of an object attached to someone else's hand, correctly, with my own hand and there was no longer any need to tell myself in what direction to move my hand.

TILTING.

I carried out the same procedure as described under this heading in the first stage of the experiment, but what happened now was entirely different. Not that the actual procedure was different, but when I moved my head from a position in which I had fixated a vertical line to that in which I held the same line in a horizontal position, I felt unable to gauge to what extent I had moved my head or through what angle I had rotated it. The result was a strong feeling of confusion which persisted while trying out this procedure during the second stage of the experiment.

Sometimes the object fixated appeared not to have changed its position at all, although I had perceived it moving; at other times it seemed to take up a sort of intermediate position. I found it difficult to express in words definitely what appeared to be happening.

This phenomenon can no doubt be explained by reference to the conflict between new and old habits. The new eye and head movements were sufficiently strong to be able to control responses, but the old eye and head movements were not yet fully extinguished, thus the two sets of habits were meeting at corresponding points on the learning curve - thus the resulting conflict manifested itself as confusion of the two sets of habits. During the quick tilting movement, the succession of stimuli which reach the retina are so rapid that they have no time to arouse the new habit structures to activity so that movement of the visual field is perceived. When, however, the head comes to rest, that movement is slow enough at times to allow the new response to be made to the new stimulus and thus the field will have appeared not to have moved. Taking into consideration the nature of the learning curve and the extinction curve, the result at this point is not surprising. It is obvious at this stage that the process of

perceiving visual stimuli correctly is subject to the normal laws of learning.

When driving in the car and watching the landscape I was able to perceive specific objects and the general layout which I had not been able to perceive during the beginning of this experiment.

VISUAL AND TACTILE STIMULATION.

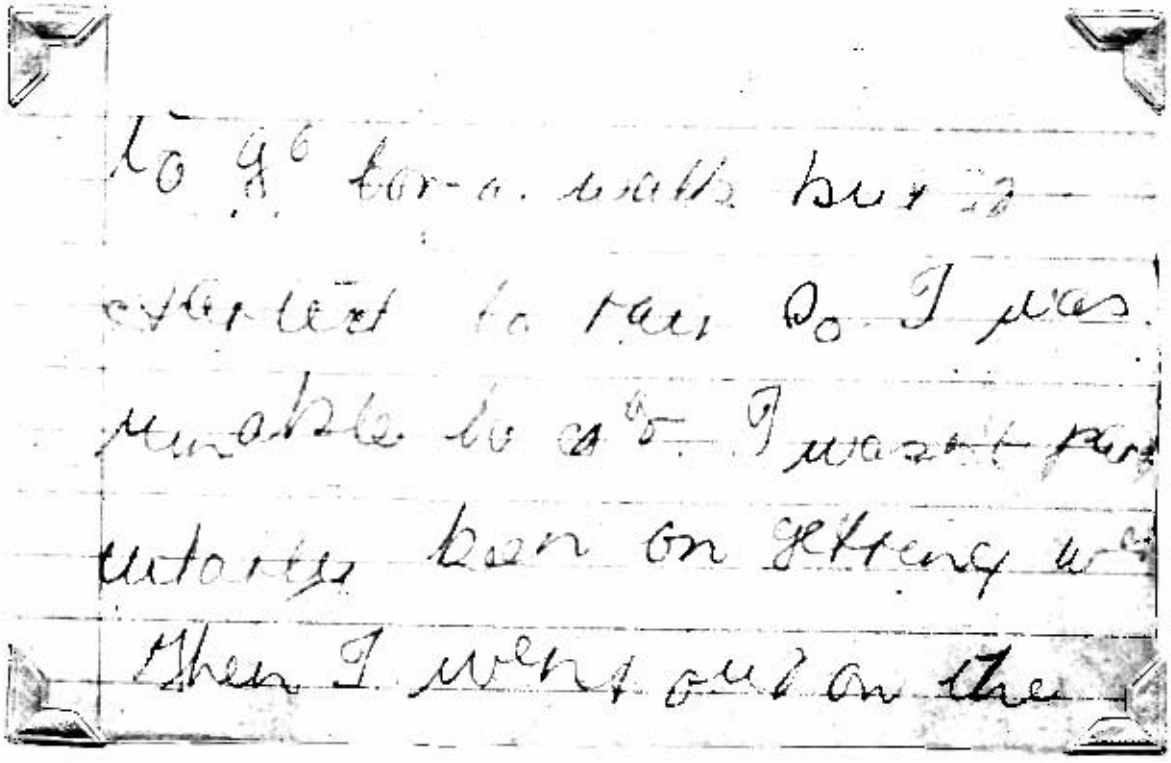
In certain situations the tactile stimulus still remained the dominant one. For instance, when trying to put the key in the lock of my desk drawer I saw the key the right way round. I saw it correctly in my hand before actually putting it into the lock. Again, when I took my hair-brush in my hand and held it directly in front of me, I saw it correctly.

Thus the relationship between tactile and visual stimulation always is an important contributory factor towards perceiving correctly. The tactile stimulus, if strong enough, can superimpose itself upon the visual stimulus to the extent that correct perception will result in spite of the altered pattern of retinal stimulation.

Nevertheless, incongruities of the visual and tactile fields were beginning not to be as marked as they were in the first stage of the experiment. It is not surprising that in the first and second stages of the experiment any transformation which did occur was a tactile transformation, but later on as habits became more integrated and adapted to the changed stimuli the transformation was a purely visual one; this of course will be clear in the third stage of the experiment.

It no longer felt so incongruous when touching people and objects because my movements generally resulted in contact with the desired part of the object. Thus now, when I wanted to touch the back of someone's head, I managed to touch the back of her head and not her chin, as was formerly the case. The sensation of being in two worlds at once still cropped up occasionally, though, but very seldom.

WRITING.



Above is shown a specimen of my handwriting during the second stage of the experiment.

It is obvious that although the handwriting is anything but normal it is definitely an improvement on the first stage effort. I still found it difficult to keep straight on the line and not go round it.

What has occurred in the writing example is analogous to what has been occurring throughout the second

stage of the experiment.

With the example of handwriting is shown how the conflict of old and new habits was progressing. By this stage I was no longer responding to the old proprioceptive stimuli but to the new visual proprioceptive stimuli, so that there is a conflict between the two sets of habits which are at more or less the same degree of strength. However, the new habits have already gained in strength to the extent that they are dominant most of the time, that is, where the actual formation of the words is concerned. But when it comes to relating these words to a specific position in space, that is on a straight line, there still remains the difficulty of the conflict between new and old spatial habits in specific instances, and this being one of them, the result is words written in between the lines and not exactly on the lines. But already towards the end of the second stage, before I had experienced continuous correct perception, my handwriting was already quite normal. Here I had the opportunity for quick learning of appropriate hand movements in response to the altered retinal stimulation and thus I feel that the length of time spent on writing while I had the spectacles on was extremely valuable because it acted as an impetus to

acquiring other new sets of habits.

New writing habits were firmly established before perceptual transformation had actually taken place.

RESPONSES TO AUDITORY STIMULATION.

There was no noticeable incongruity between auditory and visual perception. Sounds from objects out of sight were as normally perceived and when the object was in sight the sound appeared to come from where the object was actually perceived.

It would be appropriate to mention here that during the latter part of the second stage, verbal behaviour was extremely doubtful at times. If asked whether objects were pointing up or down, I found it difficult to say definitely whether they were upside down or not. It was only when the object concerned had some obvious relation to another object which was pointing in one or the other direction that I could state with conviction whether it was upside down or not.

I should say that this apparent confusion in verbal behaviour is merely a manifestation of the internal conditioning process which is occurring and where there is also a conflict of new and old habits and a certain

degree of verbal adjustment is also necessary. After all, verbal behaviour is as dependent on the activation of brain structures as is motor behaviour and both are affected by the altered pattern of retinal stimulation.

PHYSICAL ORGANIC REACTIONS.

There were no longer any sensations of nausea or giddiness during the wearing of the spectacles. While I was actually carrying out any sort of activity I no longer noticed any feeling of insecurity but my eyes continued to feel tired most days after having had the glasses on for a few hours, but not as strained as in the beginning.

EFFECTS AFTER REMOVING THE APPARATUS.

Return to normal vision took a shorter period of time than formerly but the blurred vision still remained for from half-an-hour to an hour. The visual field still appeared somewhat peculiar and movements out of place for a while.

Apparently the new co-ordination is not merely

specific for the particular experimental conditions because when these conditions are changed - that is, the glasses are removed, there appears to be some transitory influence on reactions to ordinary objects.

There was marked interference in motor activity after return to normal vision but this only lasted for a few moments. Removal of the spectacles during this period was accompanied by a feeling of depression which manifested itself as extreme irritability.

SUMMARY OF SECOND STAGE.

(i) I had now begun to react in a new way to a new system of stimuli.

(ii) Movements were smoothly executed and arrived at their respective goals.

(iii) Some new habits are likely to be acquired more readily than others so that at any given moment total behaviour might have a mixture of new and old habits - for example, tilting phenomenon.

(iv) During actual activity there was no longer a marked sensation of the incongruity of things.

(v) There appears to be evidence that the new habits necessary for the correct perception of objects in space is quickly learned during the up-down reversal. This is no doubt due to the fact that the position of objects in space is not actually disturbed by the up-down reversal, although at first it appears to be.

(vi) If two opposing sets of habits are in operation, the one which at the moment is stronger will determine the perceptual outcome: For instance, tactile and visual stimulation, and the conflict between old and new habits.

Thus there are actually these two processes going on at the same time, namely:-

(a) The extinction of the response evoked by visual proprioceptive pattern, and

(b) The gradual building up of new responses to the same visual proprioceptive pattern.

(vii) A stimulus moving across the visual field will evoke the correct response during this stage of the experiment, if the movement is slow, but if the movement is rapid, it is likely to give rise

to an incorrect response. This is illustrated very clearly by the tilting phenomenon.

(viii) New habits have been built up but have not yet been firmly integrated.

THIRD STAGE

S T A G E III - 1 WEEK.

The situations in which the glasses were worn were the same as formerly.

GENERAL IMPRESSION OF THE VISUAL FIELD AS A WHOLE.

The swinging and swaying of the visual field had completely stopped and the narrowness of the field had also completely disappeared. This was undoubtedly due to the fact that head and body movements were no longer at all exaggerated and also that having learned to respond correctly to individual objects this specific reaction became generalised to other objects in the visual field and then to the whole visual field itself.

At this stage when objects and people were all the right way up, there was still a slight tinge of unfamiliarity about certain things. For instance, this was rather noticeable when looking at things in my own room, but when I went outside and in the street I did not feel this slight sense of unfamiliarity at all. This discrepancy is probably understandable by reason of the

fact that I know my own room so well that even were I blindfolded I should still be able to find what I wanted, whereas the same cannot be said for the street outside and the park nearby. This, then, implies that knowing my room better than any other place means that having to extinguish that learning and build up new learning in order to perceive the room correctly would be a more difficult process than other learning processes where the habits to be extinguished have not been conditioned so strongly.

The transformation to correct perception having taken place need not necessarily imply that as soon as I put the glasses on my perception of the world around me was immediately correct. On the contrary, throughout this stage it took about 10-15 minutes' wearing of the glasses before the transformation occurred. The last few days, however, it only took about five minutes.

Neither did this correct perception mean that every single object was perceived the right way up. This was not the case, for instance, with printed matter. I was not able to see printed matter the right way up, and even my own handwriting, on looking back at it, I could not decipher. I could, however, work out what the headlines of the newspaper were, but no more.

For instance, the book-case in my bedroom was obviously standing the right way up, but when I looked closely at the printed titles of the books I was unable to make out any of them. No doubt, if I should have continued the experiment a few more weeks, even printed matter would have appeared the right way up.

LEFT - RIGHT REVERSAL.

The left-right reversal had ceased to be the cause of any difficulty already in the second stage of the experiment. I was able to report definitely now that I was seeing objects on the left and on the right respectively, when they actually were in those positions. New habits had been built up and old habits successfully extinguished in response to the altered visual pattern of left-right stimulation.

REACTIONS TO OBJECTS AND PEOPLE WITHIN THE VISUAL FIELD.

As I mentioned before, the most obviously incorrect perception I had was of people, and that also took the longest period of time to right itself. I had already perceived numerous odd objects the right way up

before I saw any human being correctly. However, when I did see them correctly, the whole visual field appeared completely harmonious and correct. At first it was not until I came fairly near to anyone before I saw him or her the right way up.

There is no intermediate position between incorrect perception and correct perception. I looked at a person sitting in the easy chair, and he was definitely on his head; I then looked away and a second later looked back again, and then he was sitting the right way up. This sort of occurrence was very frequent and each time it occurred I did not cease to be amazed. This stage of the experiment was positively enjoyable. The second stage of the experiment was often accompanied by a great deal of despondency, especially after I removed the glasses.

I was now able to respond to objects and people in the usual way as I was now seeing them in the way in which I always did see them without the spectacles.

At no time did I find the actual apparatus heavy or uncomfortable, only the black cloth around it tended at times to fall into my food and thus I had to contend with an additional disrupting factor, but that was soon rectified.

MOVEMENTS.

Reaching and grasping movements were all accurate and successful, as were walking, avoidance and fixation movements. Once the correct fixation movements had been firmly established in response to the new retinal stimuli, correct perception resulted. Normal fixation movements had been successfully reversed during the course of the experiment as a result of trial and error learning. The strong link between motor activity and the resulting perception cannot be over-emphasised. If the correct movements were not firmly established and evoked unhesitantly there would have been no transformation. Where undue emphasis is placed on other types of behaviour, namely verbal behaviour, the perceptual transformation does usually not occur.

Dr. Kohler reported, from Innsbruck, that when subject adopts a critical attitude; when he was constantly asking himself whether he was seeing correctly or not and constantly telling himself what to do and what not to do, the perceptual transformation did not occur. That is why I tried to avoid telling myself what movements to make and what movements not to make.

In order to get perceptual transformation it is necessary that all responses evoked by visual trans-

formation should be in harmony with the true position of objects in space, therefore in harmony with one another. Thus it follows that there could be no transformation if verbal habits continue to belong to the old system.

TILTING.

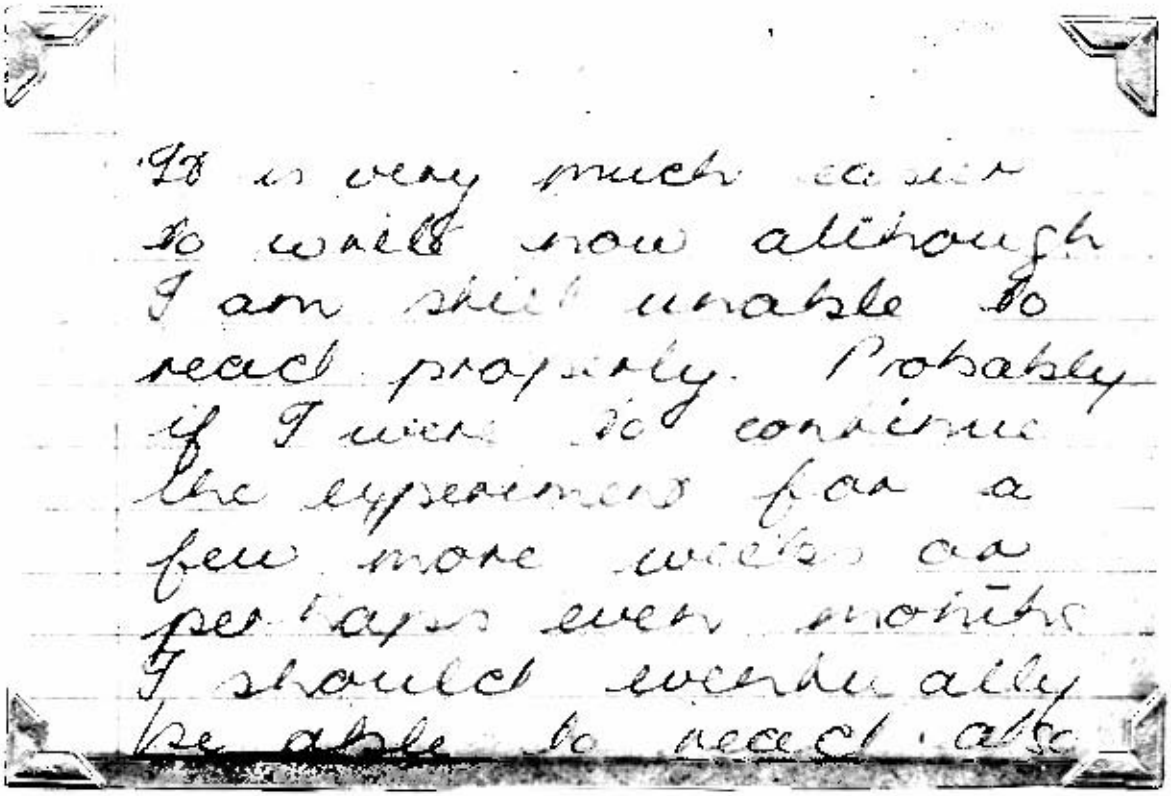
The effects of tilting during this stage were the same as without the glasses. The object remained in its correct position. This is no doubt due to the fact that the stability of the perceived world was now firmly established in the same way as without the glasses. Even during a sudden movement of the head the object fixated remained stable, as it would in normal circumstances.

VISUAL AND TACTILE RESPONSE.

There was no longer the complete incongruity between visual and tactile sensation. The visual responses now having become correctly and firmly integrated, there was no longer any cause for conflict between visual and tactile stimulation, thus there was no longer the confusion prevalent during the second

stage of the experiment. I no longer felt as though I were sometimes in two different worlds at the same time, as I did before the integration of the new habit structures had been soundly established.

WRITING.


It is very much easier to write now although I am still unable to read properly. Probably if I were to continue the experiment for a few more weeks or perhaps even months I should eventually be able to read also

This above is a reproduction of my writing during this stage of the experiment. My handwriting here is exactly the same as it would be without the glasses on.

The development in learning how to write again while wearing the glasses is a clear illustration of how the learning process, that is, the building up of new habits, functions under conditions of inverted retinal stimulation.

First of all, there was the reliance on responses to old proprioceptive stimuli; then this was found to be no longer effective in view of the strength of the inverted retinal stimulation. Thus new habits had to be built up corresponding to the new responses and in the third stage there is the consolidation of these new responses. Once the necessary hand movements were acquired, writing was simple and smooth.

Reading printed matter is more difficult in that new patterns of behaviour have to be acquired in response to each individual word and the overt behaviour is essentially restricted to movements of the eyes and one has little means of checking one's responses.

However, from the theory of perception it follows that once the necessary eye movements have been firmly conditioned to the altered stimuli, even printed matter would appear the right way up. But it also follows that learning to read would inevitably take longer than learning to write because of the nature of the new habits which have to be built up in order to enable

printed matter to be perceived correctly.

RESPONSES TO AUDITORY STIMULATION.

Responses to all auditory stimulation were quite correct, as was already mentioned earlier on in the experiment.

Verbal behaviour was no longer puzzling or confusing. I could state quite emphatically that objects and people were the right way up, and that printed matter was still inverted. Thus new verbal habits had also been established.

PHYSICAL ORGANIC REACTIONS.

There was no feeling of physical discomfort accompanying the wearing of the spectacles. However, my eyes still occasionally felt tired, but I think that would have been the case even if I had not been wearing the spectacles.

EFFECTS AFTER REMOVING THE APPARATUS.

Immediately on removal of the apparatus, the visual field appeared quite normal; blurring had quite disap-

peared, as had the excessive head and eye movements and other exaggerated motor activity.

SUMMARY OF THIRD STAGE.

(i) The third stage of the experiment is characterised by erect perception of specific objects and of the whole visual field in general.

(ii) Although the visual field was perceived as being the right way up, printed matter still appeared reversed.

(iii) Except for the latter point and the fact that there was still a slight atmosphere of unfamiliarity coupled with familiarity in perceiving well-known places such as my own room, there was in general no difference between having the glasses off or on.

(iv) The visual field took a shorter period of time, namely a few minutes, to return to correct perception, both after the glasses had been removed, and after they had been put on.

(v) New sets of habits set up in response to the reversed visual field no longer affected the old habits which came into being spontaneously when the glasses were removed.

RESULT OF EXPERIMENT

After seven weeks of wearing inverting prisms for an average of four hours a day, the visual field was perceived as being erect.

C O N C L U S I O N S

On the basis of the results obtained from this experiment, numerous conclusions can be drawn:-

(i) That the hypothesis has been verified by observable fact. The observable fact in this experiment being manifested as objective adaptation to the experience which was observed by other people, not only myself. Thus the results of the experiment were verified by objective as well as introspective evidence.

(ii) The results have added proof to the theory that perception is the outcome of the acquisition of habit structures.

(iii) Sound was found to be relatively a non-contributory factor in the breaking down of old patterns of behaviour and the acquisition of new ones.

(iv) Prediction and active planning play a relatively minor role in the process of adjustment to the

altered retinal stimulation.

(v) Adaptation begins in a specific manner but as the experiment proceeds it becomes generalised to other modes of behaviour until the numerous behaviour patterns become thoroughly integrated and when this is achieved harmonious perception follows.

(vi) The visual receptors are not necessarily the dominant localising senses throughout the experiment. In some instances, the dominant stimulus is a tactile one and the response is made accordingly.

(vii) It is not only the visual system which is reorganised but there is a certain amount of internal conditioning which has to take place, as well as a reorganisation of a certain degree of verbal behaviour. These points are supported by the feelings of giddiness and nausea and the failure of accurate verbal behaviour. Visual and tactile stimuli influenced each other, and what were the more definite conditions under which harmonious perception occurred.

(viii) As soon as I had learned to execute the reversed pattern of head and eye movements spontaneously, it follows that I should have and did perceive objects and people fixated, in the centre of the visual field. Therefore, when fixation movements in all possible directions had been firmly established as habitual responses to peripheral stimuli the visual field must be perceived as being erect.

Thus it follows that when fixation movements in response to peripheral stimuli from printed matter will be firmly established as habitual responses, then printed matter would also be perceived as being erect.

(ix) It is apparent from this experiment that perception of distance is also affected by inversion of the visual field and that new habits have to be acquired in response to the changed perception of distance.

(x) In order to get correct perception, two things are necessary:-

(1) Inhibit existing habits;

(2) Build up new habits, in response to inverted retinal stimulation.

(xi) The results of this experiment have clearly shown that by means of active training during the wearing of the spectacles the transformation from inverted to correct perception will occur. It is not essential (as was previously thought by Stratton and the other experimenters) that consonant with the wearing of inverted prisms or lenses all direct stimulation of the naked eye must be painstakingly avoided.

The essential feature is that new responses be built up and old responses broken down during the actual wearing of these spectacles. The fact that on removal of the spectacles old habits are once more reinforced does not prevent the new responses to the new stimuli, the result of wearing the spectacles, being built up. The salient feature is that an active opportunity is provided while the spectacles are being worn, for the new patterns of behaviour to become firmly integrated and established. Thus throughout the course of the experiment emphasis has been laid on active behaviour.

The results obtained as an outcome of the particular circumstances of this experiment can only be logically explained if we regard perception as being functionally dependent on the qcquisition of habitual patterns of behaviour. Perception is not a single reaction but a whole complex system of reactions to a variety of stimuli in the immediate environment. Therefore perception is behaviour directed towards the environment which arouses it.

It follows, therefore, that if one's behaviour towards one's environment changes, one's perception of that environment will change accordingly.

In this experiment the fact that vision for most of the day was normal was insignificant in that the only direct bearing it had on behaviour during the wearing of the spectacles was that it prolonged the learning process to eight weeks instead of a few days as with Stratton and Dr. Kohler's subjects. And then it was not the normal vision which affected the learning process but the fact that wearing the spectacles for only four hours each day gave me only four hours a day in which old habits could be extinguished and new ones acquired, as opposed to the sixteen hours a day of other subjects who undertook the same sort of experiment.

It is apparent from this experiment that no adjustment would have been possible without the accompanying motor activity and the actual visual perception of the errors one is making is an extremely effective incentive to correct the errors. The errors refer to errors of movement and localisation.

The results of this experiment have proved the hypothesis that differential training in response to inverted retinal stimulation will bring about transformation of the visual field so that it is perceived as being erect.