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VISUAL PERCEPTIONS AND JUDGMENTS.

I hereby declare that the following thesis, entitled

"Visual perceptions & judgements"

is entirely my own production.

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For list of books consulted see last page.

VISUAL PERCEPTIONS AND JUDGMENTS.

The poet Longfellow tells us, that "things are not what they seem". The endeavour of this paper is, to show that at any rate, things are not what they look. We will see at the finish that it is by the activity of what we call the "mind" building up the various sense-data derived from different channels that we are able to perceive and judge of the character and disposition of objects in the external world.

The subject is a complex one, and the deeper we dip into it, the more difficult it becomes. Old theories are upset, new ones are formed, only, at the end to leave many enquiries unanswered. Our perception and judgment is not a mental image, corresponding to that formed upon the retina, is not extra mentally formed from any channel, but is constructed by a synthetic process. We know something of the laws and value of this synthesis, of the process it-self we know nothing.

At the outset we must carefully distinguish between a visual sensation and a visual perception.

The one is a physiological, the other a psychological process. The mere change of consciousness by which we distinguish an object whose image has been formed on the retina, constitutes a visual sensation, the after effect by which we perceive of the object is a visual perception.

Although the one follows upon the other, we are capable of disassociating the two in our minds, e.g., when we see a flash of lighting, we are conscious of a luminous sensation, the psychological process by which we refer it to a certain position in space, is a perception.

In common parlance, we use the term "feel" to represent the physiological process, "perceive" to represent the psychological, thereby showing our power of distinguishing one from the other.

Just as the perception follows the sensation so does the judgment follow the perception and thus no hard and fast line can be drawn between them. For visual judgment "secondary helps" are necessary. The other senses, the muscular sense, and the experience derived from previous perceptions and judgment, are some of the secondary helps which teach us that an object is at a certain distance in space, which teach us of its exact position with reference to neighbouring objects, and enables us to distinguish its size, form, solidity, and movement.

An external object is focussed upon the retina. Visual impulses are immediately generated, which pass along the optic nerve to the cerebrum, these cause changes to take place in the visual centres altering the impulses into something else at present unknown, which causes a sensation.

Here physiology ends, psychology begins, but upon the distinctness and sharpness of the retinal (physiological) image, depends the distinctness and sharpness of the after-visual (psychological) effect.

Physiology may however be at fault,(there may be fault in the retina, - or the changes in the cerebrum may give a wrong impression) or the psychological results may be at variance with the object looked at. We will have to discuss each of these in their proper place. It may be mentioned here, however, that some sensations give rise to perceptions which are demonstrably different from the objects which cause the sensations.

These are spoken of as "illusions."

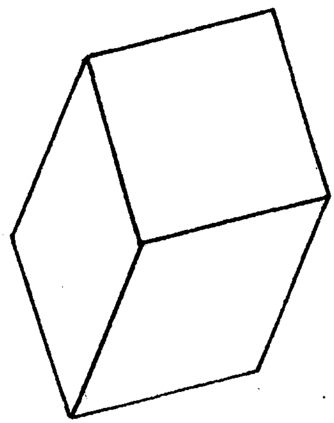
The mind is capable of reviving an impression which has been strongly fixed upon it, many months or years after the initial perception, e.g., if we carefully study an anatomical figure, and "fix" it upon the mind, it is capable of being revived again, whenever wanted for examination purposes or in the everyday needs of practice. This revival of perceptions, we call an "idea". Although retinal images are formed, the mind must be concentrated to a certain extent before the images are perceived.

With our attention directed to something else it is possible to look upon a landscape and yet perceive nothing of it. It is possible when looking at a book to direct the attention to some other subject, so that no perception of the words is realised.

The degree of clearness with which we perceive objects and fix them upon the memory, or with which we can apprehend previously formed impressions, is brought home by a manifold experience to all, and is dependent upon the subjective activity of the mind excited by activity of the will. Our will is predominant. We can attend where we will. In looking through a microscope with both eyes open we can suppress the image formed in one eye altogether and direct our attention to the one we desire to see.

Many images which are formed upon the retina are capable of more than one interpretation by the mind of the observer. We can choose which we will by the voluntary concentration of attention. In Fig., 1, first one corner,

FIG., 1.



and then the other can be drawn forward at will. It is also possible by a great concentration of the mind to perceive an anticipated visual effect.

To get an accurate fixation of an object upon the mind so as to be able to recall it for after use, we must direct our attention to its various parts, and then study it as a whole.

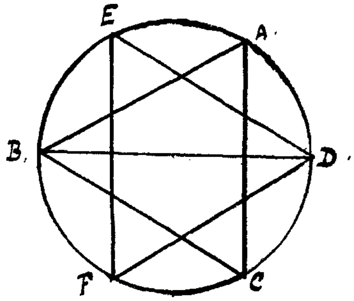


FIG., 2.

In Fig., 2, we have two equilateral triangles, six angles near the outer circle, and a hexagon in the centre. We must get a correct appreciation of each of these parts, the imagination, will combine them, together with the outer circle into one figure, capable of being recalled when desired. Again, if we cast our eyes over a flat piece of ground we have a sensation of dreariness and loneliness. But let this same landscape be studded with houses and trees, we have a much livelier sense of imagination, and we talk of the beauty of the scenery. This depends upon the movements of the ocular muscles, and the variety of the images formed upon the retina, which excite the imagination and give a sensation of relief to the situation. For this reason, architectural ornaments are much more pleasing than a flat surface, and in the same way carvings in high relief than shallow or flat ones.

In order to appreciate their beauty, the attention must be fixed, we must accommodate and relax our accommodation, move our ocular muscles so that different impressions may fall upon the central retina. Varied and quick changes in the imagination, then, excite a feeling of liveliness for the time.

But as concentrated voluntary attention implies loss of energy in the cerebrum, it is possible for the imagination to tire, and be less susceptible after a time.

After viewing a museum, or a picture gallery, we experience a feeling of lassitude. So also after a railway journey, through a new district, or passing up a river in a boat, we have a much more correct and lasting impression of the objects perceived at the beginning of the journey when the imagination is fresh than towards the end, when it becomes less easily excited. We may be wrong in saying that it is the imagination alone which is tired, it may be that the ocular muscles, through the long continued nerve impulses sent to them, which impulses cause movements quick and varied in direction, excite by sympathy a feeling of lassitude At any rate, we know there is headache, and we also know that if one part of the body be moved to excess while the remainder is practically at rest, the feeling of lassitude is not confined to the part moved, but extends to the whole body, although in lesser amount.

We are sometimes aware of perceptions without any excitation of the retina, otherwise than its own molecular activity, which has been called the "proper light of the retina". On closing the eyes at night we sometimes see objects well defined and marked. In some cases these may be the revivals of sensations experienced during the day, stored up in the mind, and set going again by something of which we cannot tell the nature. These are spoken of as recurrent sensations. Several hours after a prolonged microscopic examination, we may sometimes perceive the objects which were seen in focus, distinctly, in front of the eye. In other cases, however, the perceptions are altogether different from anything we may have perceived in the course of the day. The molecular activity of the retina, which needs no visual excitation to set it going, may act upon the central visual mechanism so as to give us an impression, but why it should be defined we cannot say. It may be argued that the retina has nothing to do with the formation of the impulse, that possibly it is set up in the central nervous system itself, by some accidental circumstance, such as an increase or diminution of the blood pressure, or some accidental molecular activity of the nerve cells themselves.

These false perceptions, equally as distinct as those produced as the result of visual perceptions, may be sometimes experienced even when the eyes are open, when the retina is excited by light and visual impulses are being carried to the brain.

They are then spoken of as hallucinations. This would almost make us incline to the idea that there is some pathological or molecular change in the nerve cells of the central nervous system connected with vision, and that the retina plays a very small part in causing the sensation. The retina is active, impulses are sent from it to the cerebrum, producing a perception of the ordinary kind, but that produced on the central nervous system predominates, altering or changing the other perception in part, at any rate. Witness the man in delerium tremens, who sees rats running all over the room. Here we have a direct excitant to the nerve cells in the absorbed alcohol, or its derivatives. Again, in cases of insanity, where it is most probable that there is some pathological change in the nerve cells of the brain.

Many people suffer from delusions. The mind gives a false colouring to a real occurence. It works up into an apparition, the sight of some commonplace object, investing it with the results of previous experience, and fully believing the judgment then formed. Not only may this delusion be confined to one, but a number of people witnessing an occurence at the same time, may run away with the same false idea. It is said that "seeing is believing", but our sight, or rather the interpretation put upon our sight, may delude us. In previous ages, spirits were constantly seen, in our time, people often see ghosts, and the spiritualistic and theosophical seances are fully believed in by many to-day. The mind becomes possessed with one dominant idea.

But cerebral activity may go on unconsciously. When dreaming we may have a picture of something before our eyes entirely different from anything we may have previously recognised. We even find persons, when wide awake, and who can be trusted in every other sense, describing visual impressions, which they felt which have no foundation in fact. It may be therefore possible that the spiritualistic believer truly sees the wonderful things he talks about, although there is no reality in them.

If the subjective impressions arising from unconscious activity of the cerebrum be once perceived, there is no reason why they should not be registered in the mind, equally with those caused by retinal impressions.

An exact image of the object looked at is formed upon the retina, but this image is inverted. We perceive the object however in its erect position. Why do we perceive an object whose image is formed on the upper retinal surface in the lower part of the field of vision, and if an image is formed on the nasal side of the right eye, why do we become aware of it as situated towards the right? Again, why is the object seen as erect ?

It has been asserted that children see all objects at first in an inverted position, and only come to see them as erect after the experience derived from the tactile sensations by handling and moving them. But this theory starts from a wrong basis. The "mind's eye" is not situated behind the retinal image, so as to see it, the mind translates the subjective into the objective, and it is equally as natural for the retinal impression to suggest an erect posture to objects as an inverted one. Again, persons who are born with congenital cataract, who have had the lenses successfully removed in later life, see objects in the erect position.

The mind refers all sensations to the exterior. Touch, taste, hearing, smell, are all perceived as being in the external world. In the same way the retinal image, whether produced by objects outside or inside the eye, is perceived of as existing in the exterior.

We are not conscious of the retinal image. It merely sets up a sensation of light in the cerebrum and localises the different parts of the object with reference to each other. When we refer it to the external world, we necessarily project it in the direction from which the rays come, and therefore see it as erect. We refer it to the exterior along a line drawn from the part of the retina excited, through the centre of the pupil.

If the image therefore is formed on the nasal side of the right eye, we refer it to the right side, and, as we can touch objects lying in this situation with the right hand, we speak of it with reference to the mid line of the body, as being to our "right". Similarly an object formed on the nasal side of the left eye, is referred to our "left", and an image formed on the upper part of the retina is referred to the "lower" part of the field, where touch through the medium of the feet can again assist us.

Touch always perceives objects in the erect posture.

The point to remember is that when we use the terms "right" "left" "upper" "lower" for localised sensations of light, we are being informed by our feelings of touch, and no primary reference to the field of vision is considered.

But there are other factors, beside touch, to be taken into account. When we look at a telegraph pole, the retina is not large enough to form an image of its whole extent. We therefore, "run the eye" over it in order to bring successive portions of the object looked at, one after the other, on the macular area. In doing this we are conscious of the movements of the ocular muscles in various directions.

When the eyes are moved downward the lower parts of the pole and the objects situated on the ground are successively brought into the field of vision, when the eyes are moved upwards the higher parts of the pole and the remoter objects come into view. Different impulses are sent from the various muscles to the brain, acquainting the mind with their condition and movement. The latter analyses these sensations and draws conclusions. In this way the muscular sense assists us in localising the objects.

In arriving then at a correct conclusion of the erect posture and locality in space of an object, we have, first of all the physiological act excited by the sensation derived from the formation of the image on the retina, referred to the source of light, assisted in more complex analyses by the experience derived from the other senses, and particularly that of touch, and further assisted by the muscular sense, through the mental excitation derived from the movements of the ocular muscles. Although as we have seen, objects in the external world, are always referred to a position in space, the mind has been so habitually trained to refer objects to the exterior, that images formed on the retina by objects within the eye are also referred to positions outside the body. Of this nature we have the troublesome muscae volitantes which are a source of much annoyance and discomfort to a large number of people. Slight opacities are formed in the vitreous humour, which cast their shadows upon the retina. Although at first they seem to be in the eye, the mind soon refers them to the exterior, and they are seen in front of the eyeball. In the process of time, however, it is possible for the mind to disregard them altogether, and yet leave the field of vision quite complete.

Light is the usual excitant of the retina, but it is capable of reacting to other stimuli as well, and every excitation of the retina produces a visual impression which is referred by the mind to the exterior. So accustomed are we to receive our sensations of light from the external world, that we disregard the retina altogether, and seek outside the eye for the source of the impulse and for excitation of different parts of the retina, we seek in the external world for the cause, in such situations, as we are accustomed to receive the luminous rays from, e.g., if the upper part of the retina be excited, we know, by experience that the dioptric arrangements of the eye are such, that an impression could only be caused on this part of the retina, by an object lying in the lower part of the field of vision, and we seek in this direction for the cause.

For this reason if we excite the retina by pressure by the finger, by a blow on the eye, or it has been said, by rapid accommodation, we have luminous impressions (phosphenes or phosgenes) referred to the exterior. So also, if we excite it by a strong electrical current. At the moment of making and breaking, we are conscious of luminous rings, with a more luminous centre referred to the exterior. But the retina has a light of its own, proper light of the retina, for its nervous elements are in a continuous state of tonic excitation, brought about by the changing supply of blood to it, or possibly to the central visual organs. Although this is not constant in degree or quantity, we are sometimes able with the eyes closed in a dark room to see a bright & distinct coloration. But for the above mentioned reason this is also referred to the external world.

It was incidentally mentioned previously that the physiological as well as the psychological act might be at fault in forming a correct perception and judgment of objects. We have now to treat of the former, and the phenomenon, or series of phenomena known as **IRRADIATION** is the first to claim our attention.

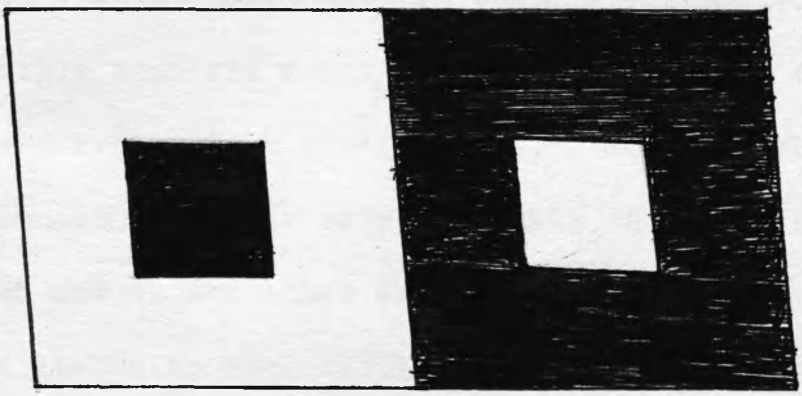


FIG., 3.

In Fig., 3, the white square on the black ground appears larger, than the black square on the white ground although they are mathematically of exactly the same size, and whereas the white square appears larger than it really is, the black square appears smaller. Similarly, if we place two white squares on a black ground with a small space between them, they would appear to us to be nearer together than they really are. Helmholtz was the first to give an explanation of this. It is most easily seen if the eye is out of focus, and is most probably caused by the circles of diffusion formed from the white surface encroaching upon the dark spot. Darkness is the absence of rays of light from structures which are sensitive to light, a part of the retina is therefore not excited when we look at the figure. The spectrum tells us that the white light from the white surface is made up of various colours, red, orange, yellow, green, blue, violet, but these rays of light are not equally refrangible, although it is possible that the media in front of the lens correct the chromatic aberration to a great extent. To focus the red rays, a stronger accommodation is necessary than to focus the violet rays, which are at the other extreme of the spectrum, and we are therefore liable to have circles of diffusion formed. If it were possible for us to focus all the rays which compose white light equally upon the retina, no circles of diffusion would be formed and the white square would appear of its natural size. The unstimulated part of the retina is most probably encroached upon by these circles of diffusion, causing a larger retinal image than ought to be formed, and, therefore, an increase in size.

Conversely, when we look at the black square, a part of the retina is less excited, but the surrounding part is strongly excited by the white rays, and the circles of diffusion encroach upon the unexcited part of the retina, causing the black square to appear smaller than it really is. In fact, it is probable, that whenever vision is directed to a white surface, circles of diffusion are formed encroaching upon the other parts of the retina, so that we do not see the white surface as it really is but of larger dimensions. Other phenomena leading to a false perception and judgment due to the physiological act have now to be considered, more particularly those questions referring to after images and the contrast of colours.

White light is made up, as shown by the spectrum, of different colours, and upon the number of oscillations of the luminiferous ether, depends the colour we perceive. At the rate of 450 billions of oscillations per second, we perceive red, at 790 billions, we perceive violet, and between these numbers the various other colours. There are ultra red and ultra violet rays, but the eye cannot perceive them, - a blessing for us when we consider that even with those of the spectrum circles of diffusion are formed, and the distinctness of objects is interfered with. By mixing the colours of the spectrum, a large number of intermediate colours are formed. This number is greatly increased according to the amount of white light which is intermixed, and still more increased by variations in the intensity or brightness.

Experiments have shown that if we take certain of these colours, and mix them, we produce a white light, and the two colors which when mixed together, produce a white light, are said to be complementary to each other. Thus, red and green blue are complementary, for if mixed together in proper proportions, white light, results.

Our perception of colour, is found to vary, with the time allowed for the excitation of the retina. It varies with different colours, even of the same intensity. It has been calculated that .05 seconds must be allowed to elapse before the maximum effect of red is perceived. One second for blue, and 1.3 seconds for green.

This can be shown and proved by means of a colored top, the different sections of which are coloured with the different colours shown by the spectrum.

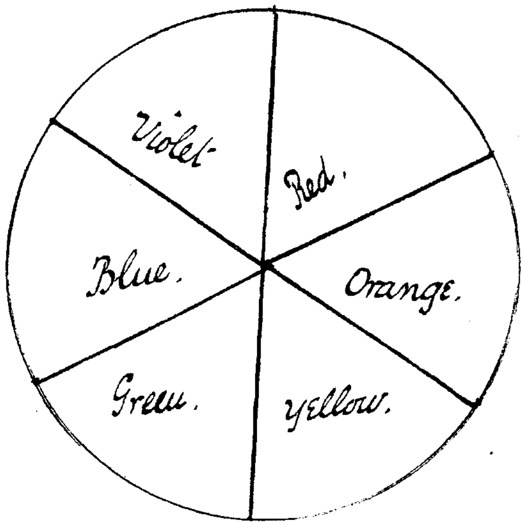


FIG., 4.

If we rotate this top, very quickly, white is the colour observed. Red is not observed till $\frac{1}{20}$ of a second elapses between each revolution, & green is not recognised till $1\frac{1}{3}$ sec., intervenes between the revolutions.

Within certain limits the perception of colour also varies inversely with the intensity of the stimulus and the size of the object. The larger the surface, the less the intensity necessary for the perception of the tone and vice versa.

Our perception also varies, with the part of the retina stimulated. A bright colored object such as a rose appears much more brilliant and of a more gorgeous hue, if looked at through a tube, when the macula, - the most sensitive part of the retina, -is stimulated, than if the whole retinal surface is excited at the same time. Peripheral images produce sensations and perceptions, which modify the central sensation, and by a further psychical progress they may be still more altered.

Rays falling on the macula which produce an impression of red, yellow, or green, if falling a few millimetres outside produce a sensation of yellow, violet on the macula, appears blue, on the surrounding zone. As we pass towards the periphery of the retina, our perception of colours becomes indistinguishable and is ultimately lost. The parts of the retina outside the macula cannot produce any sensations and perceptions which are incapable of being produced by stimulating the central zone.

These remarks can be easily illustrated by the use of different coloured wafers. If one eye be closed, and the other fixed upon the wafer, gradual removal from the central field of vision causes a diminution in its brightness and change in its colour, till at the periphery it finally appears black. We still recognize its form, and we therefore say that the fields of form and colour are not alike, that of the former being the larger.

Our perception of colours, also varies according to the condition of the retina before stimulation. In the early morning if we look at the window for an instant when the sun is shining into the room, and when the retina has been at rest for some time, during sleep, and then close the eyes, we will perceive an exact image of the window, the bright parts, (glass), bright and the dark parts, (sashes) dark. This is a positive after image. The after image is at first clearly marked, then reaches its maximum of intensity, and then gradually declines. But if we gaze fixedly at the window for some time, and then close the eyes we will perceive a negative after image with the same characteristics of duration and intensity but the dark parts will appear bright, and the bright parts dark.

The sensation of a stimulus, lasts longer than the stimulus itself. This explains the positive after image. It is referred to the exterior as we have shown are the perceptions derived from all excitations of the retina. We explain the negative after image by saying that the retina is fatigued or exhausted. We may be wrong in saying that there is exhaustion of the retina alone, for the central nervous system may be fatigued as well. We know however, that any long continued stimulus of an end organ sooner or later fatigues it, and we may therefore continue to talk of exhaustion of the retina. At any rate, the tired out area whether in the retina, or in the central visual system, responds feebly and the window pane appears dark.

When we come to consider the question of contrasts, we will see how much variation there may be, between our perception of objects and the object as it really is. If we excite one part of the retina only, the sensation derived, is not a measure of the excitation of that part alone, but also to a certain extent, of the other contiguous points in the immediate vicinity. If we blacken a piece of paper leaving a white cross in the centre, and carefully focus it on the retina, the central part of the cross will appear dimmer than the outside part. Again if we take a piece of paper and draw two parallel black stripes, leaving a white stripe between them, we can detect a difference even with the most accurate focus of the eye, between that part of the white which lies nearest to the black, and the central part of the white. The latter appears dimmer. This is spoken of as simultaneous contrast. We thus see that bright object with dark surroundings appear darker, and it can be similarly shown that dark objects with bright surroundings appear brighter. With coloured objects the phases of contrast appear much more striking. If in a good light we select from Holmgreen wools, a grey colour and a pale green colour, placing them accurately one above another, and cover them with tissue paper, we see neither a grey nor a green colour but a pink colouration, the contrast of the green. If we take a red surface and place upon it a grey paper, the latter will appear greenish blue - the complementary colour of the red. If we place it upon a blue ground it will appear as pink - the complement of the blue, and so on, by remembering the complements of the various colours we might multiply examples indefinitely. For this reason Figure 5 is appended.

Draw an equilateral triangle and mark its three angles by the three primary colours red, yellow, and blue.

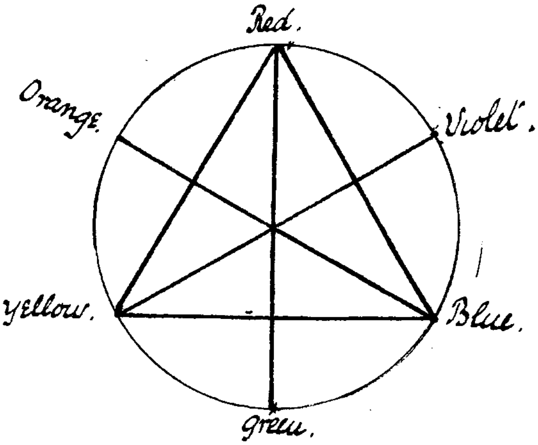


FIG., 5.

Connect these by means of a circle, and place the mixed colours in their order in the spectrum, intermediate between the simple colours. Connect those lying opposite, by means of lines drawn through the centre of the circle; those colours lying at the opposite ends of a line, would if mixed together produce white light and are therefore complementary to each other, e.g. green is the complement of red, blue that of yellow.

(In all those experiments in which tissue paper is used the contrast is less striking, and may wholly disappear, if the tissue paper is removed. In the other cases the contrast vanishes if a broad black border is placed around the small piece of paper.)

These are the simplest forms of colour contrast. When we turn to more complex contrasts as when a coloured object is placed upon a coloured surface, the figure is again of assistance to us, as the contrasting colour is the complement of the colour of the object looked at, mixed with the colour of the surface e.g., a reddish patch on a blue ground is seen as greenish blue, a blue patch on a yellow ground as greenish yellow.

These remarks are also true of the negative after images. If a black spectre on a white ground be carefully looked at for a minute, and the eyes turned to a dark part of the room, a white spectre is seen floating in front of the eyes.

If the spectre be coloured red, a greenish spectre is observed in front of the eyes. Similarly a greenish spectre on a white back-ground gives a reddish spectre in the after image. The setting sun is deep red. If we gaze fixedly at it for a time, and then turn quickly towards the east we will see a rising green sun. The coloured after image is always the complement of the colour observed. There is no necessity for multiplying examples, for by the aid of the Figure, we can always tell what colour the after image will be. With regard to the negative after image formed in the case of the more complex contrast of colours the same remarks hold true, the negative after image is of the colour of the complement of the primary image mixed with that of the surface e.g., a reddish patch on a yellow back-ground gives a greenish yellow after-image.

When we come to attempt to explain these we are met with many difficulties. They are not cases of deception: they are most probably produced by exhaustion. Let us take, for example, the case of the black spectre on the white back-ground where the after image was a white spectre. In order to bring about this result it is necessary to look intently for about a minute at it.

The peripheral parts of the retina are fatigued by the white light, but the central zone is not stimulated. We have already shown "that the different parts of the retina are interdependent in the production of sensation".

When we look at the dark part of the room then, the peripheral parts which are fatigued, re-act very much less by comparison, than the central zone which has been at rest, and the image of this part is therefore more easily perceived.

Although in all these experiments we had either to stimulate or fatigue the retina in order to produce them clearly, yet in our daily life with a lesser excitation or fatigue, we must be often receiving an altogether false perception of things as they really are.

Our perception of the colour of objects may be altered in certain pathological states and also medicinally.

Among general pathological conditions, may be cited jaundice, in which it is said that all objects appear as a yellow colour.

As an example of a local pathological condition may be mentioned that of cataract. In later life the lens changes its consistency and becomes of a yellow color, which imparts its hue in a slight degree to objects seen. If a cataract be formed, and is removed, objects then appear for some time afterwards of a colour complementary to the yellow viz:- blue,-a source of considerable discomfort to the patient for a time.

Among medicines it is well known that the taking of santonin, gives to all abjects either a bright yellow color or else its complement violet-blue. This however passes off in the course of a few hours.

We cannot leave the question of our perception of colour without a few remarks concerning the altered perception of those who suffer from colour-blindness although it is not our intention to discuss the various theories regarding it. A large proportion of our population (3 - 4 %) do not perceive the entire chromatic scale. In many walks of life the mistakes may never be noticed or have only ludicrous consequences.

It is however when we come to the various services in which coloured signals are used e.g. the railway and the marine service that the results of the mistakes of colour may have far-reaching and frequently fatal consequences.

Daltonism is hereditary and incurable. It is also congenital, although it may be produced by disease e.g. certain forms of atrophy of the optic nerve, or traumatically, and may then be either complete or partial. The abuse of tobacco may lead to a diminished perceotions of colour and even to total colour-blindness over the central (or macular) area of vision. It might be thought that the visual power of the color-blindness would be interfered with, but it is not so. By education and observation, the most common mistakes may be avoided in those who are only partially colour blind, but we have no difficulty, if various tests are used, in recognising the defect.

Just as we recognise three primary colours or colour substances, so we recognise three kinds of colour-blindness - red-green, green-red and yellow-violet. Of these red-green is by far the commonest, green-red comes next and yellow-violet colour-blindness is very rare. There are two chief theories for the explanation of colour. According to the most generally accepted or Young-Helmholtz theory there are in the retina 3 distinct sets of fibres each capable of responding to a stimulus of one of the 3 primary colours, red, green, or violet. The absence or paralysis of any one set, gives rise to the corresponding colour-blindness; the stimulation of all three to the sensation of white light. According to the second (Herings) theory which has been modified by Wundt there are 3 chemical substances in the visual purple, which answer to white and black, red and green, and yellow and blue. Each of these substances is subject to an anabolic (or a building up) and a Katabolic (or destructive) action. In the anabolic state white, red, and yellow are perceived in the three substances, in the Katabolic the complimentary sensations viz., black, green, and blue are seen. According to Hering it is an absence of change in one of these substances which causes the deficiency of the corresponding colour in the mind.

But all the speculative physiological theories, need supplementing by a knowledge of the induced conditions in the brain, concerning which we know very little. There must be a colour centre in the brain or how can we explain those cases of almost complete colour-blindness which follow injuries to the head, or ascending spinal sclerosis, even without any change in the retina as far as we can recognise by the opthalmoscope.

Before we discuss the question of perception as a whole due to "the retinal field of vision", there are two important considerations which are best got rid of now, viz.,

The question of the blind spot and the formation of Purkinje's figures.

BLIND SPOT. The optic nerve enters the eye about $\frac{1}{10}$ of an inch to the nasal side of the macula. That this part is not sensitive to light can be shown,

1. By throwing a ray of light from a small mirror (e.g. small opthalmoscopic mirror) on to the blind spot; there is no sensation.

2. Draw a small cross, and a circle, about two inches apart; close one eye and look directly with the other eye, at the cross. By gradually moving the head, or the book, backwards and forwards, a point is reached where the circle entirely disappears. The rays from the circle have fallen upon the blind spot and are invisible. Thus no sensation is excited by rays falling upon the blind spot, and it will be shown when we speak of the formation of Purkinje's figures that the optic nerve fibres of the retina are also insensible to the rays of light, and can only be excited through the medium of the other structures which compose the retina.

The blind spot being insensible it is rather curious that there should be no gap in our field of vision. It might be supposed that when looking at a large white field, the blind spot would show itself as a round oval black patch, corresponding to the area occupied by the optic disc. But black, although not a true colour, nevertheless, gives rise to a definite impression, just as any coloured object would do. At the blind spot, however, there are no nerve elements and therefore this area gives rise to no impression whatever, and consequently nothing whatever is seen at this spot, the lacuna therefore is unnoticed by the mind. For confirmation of this we have only to adduce the well known pathological occurrence of a retinal haemorrhage, which if dense gives rise at once to a dark patch in the visual field and is an object of constant annoyance to the patient.

The formation of <u>Purkinje's figures</u> is another interesting phenomenon, for, apart from its relation to visual perception, it shows that the rods and cones are the principal organs in creating visual impulses. The figure may be shown in various ways.

1. By looking at a powerful gas light, in front of which a rapid movement is made, through a small aperture in a piece of cardboard.

2. By directing through the medium of a mirror a strong beam of light on to the outer edge of the sclerotic.

3. By moving a candle backwards and forwards, so that the light falls upon the exterior of the eye. This experiment has to be conducted in a dark room with the eye fixed on space.

We see a reversed picture of the retinal vessels, branching dichotomously, floating in front of the eye on a reddish ground. It is also possible to see the fovea.

Histology teaches us that the retinal vessels are distributed in that part of the retina composed of nerve fibres and ganglionic nerve cells, and as the light of the candle falls upon these vessels from the front, the shadow must be behind, i.e., in the outer layers of the retina. These parts must therefore be able to give rise to visual impulses, in order that we may see the vessels. It is exactly in this situation that we find the rods and cones, and this is one of the considerations which leads us to conclude that these are the points of origin from which visual impulses spring, and we also conclude that the optic nerve fibres are, in themselves, insensitive to light.

Not only is it possible to see the retinal vessels but if we take proper measures we may also see the very blood corpuscles. By moving the head backwards and forwards, when looking through a long tube at a strong light, we faintly see numerous bodies which are the blood corpuscles. These like Purkinje's figures are seen as if in the external world.

We have shown how the physiological act may lead to a wrong perception, but, we have yet to show how it is that we perceive at all. That an image is formed upon the retina is certain as it can be made the subject of ocular demonstration; that impulses are sent along the optic nerve to the cerebrum may also be inferred. We have already shown the distinction between the consciousness of our being affected (sensation) and perception. Sensations are in ourselves, perceptions are however out of ourselves, and referred to a position in space. There is a wide interval between these which the mind bridges over.

We now enter the domain of psychology. Of the initial bridging over we know very little, but ingenious theories have been devised to explain it, the two principal ones which hold sway at the present time being the "Empiristic" of Helmholtz ("genetic "Wundt") and the "Nativistic"(or intentional) of both Helmholtz and Wundt.

The followers of the "Empiristic" theory hold that the mind is built up from the sensations derived from the other senses, especially those of touch, and the muscular sensations derived from the movements of the eye, whereas, the"Nativistic" theory infers a certain underived activity of the mind, a something native to the mind by means of which through the stimuli excited by the activity of the retina, it becomes aware of space.

These theories although rival to a certain extent are not radically different; they merely attempt to explain certain recognised data by different processes.

We must take it for granted that the mind has a "psychological equivalent" in the sensations which are produced through stimulating the retina, for without this no satisfactory explanation of perception can be given. We must go even further, and say that there is a different value in consciousness, for stimulation by light and colour of different parts of the retina, and as we know that each retinal cone is a distinct sensitive element, there must be correspondingly small equivalents in consciousness.

The characteristic difference between sensation and perception is, "space form", the object observed has a certain position in space, bears a certain relation to other surrounding objects, and is made up of an indefinite number of different parts. Our appreciation of this in later life is a mental achievement, and correct results are only produced by a long mental training, by laws of the mind itself.

What is the starting point ? Is there something native to the mind or, is the mind merely a "genesis" of the activity of things ? To get a correct answer we would naturally turn to the beginning of consciousness as shown in the child. But we are met at the beginning by the difficulty that the child is unable to tell us its initial experience, and even if it could, it is unlikely that it could explain to us the process of its mental development, so that we could judge between the two theories.

Since the child can give us no assistance, our next best method of studying perception, is to observe the result of blindfolding both eyes. Allow time for the after images both positive and negative to disappear, and keep the eyes as motionless as possible. We now see only an undefined expanse of "related color sensations" due to the constantly changing molecular activity of the retinal elements. The retinal field has now no clearly defined limits, but it has a true spatial expanse. What we perceive has a system of points of light and color lying side by side and each smallest part has relation to the other part. It cannot be said to have depth, although an appearance of depth, is brought about by changes in the color and brightness of the minute portions of the field. If we keep the eye motionless, and move the head, the retinal field moves at the same time, and we are able to locate it with reference to the body. We can say whether it is above, below, to the right, or to the left, but we are enabled to say so, only, by calling up our previously formed sensation of touch, combined with those sensations derived from the muscular sense by moving the muscles of the neck.

If we now keep the head fixed, and move the eye, we can tell the extent of the field. It cannot be that the movements of the eye are bringing different images on to the retina, for there is no change in the position of the field. It can only be that we are calling up our previously formed ideas derived from the muscular sense. This is one of the arguments in favour of the "Empiristic" theory.

Again, what we see when the eyes are blindfolded is not the result of the activity of one retina alone, but of both. This can be shown by opening one eye, and allowing the other to remain closed. The open eye sees everything lying in the monocular field of vision, plainly and distinctly, but if we excite a phosphene, by pressure in the closed eye, and fix the attention, it is possible to overcome the perception of the open eye, and see only the colored circles produced by the excitation of the retina of the closed eye. We can look upon the two eyes to a certain extent as one organ, but we must remember that the perceptions derived from one eye are influenced to some extent by the sensations derived from the other. This is another argument in favour of the "Empiristic" theory, for its followers say that the mind is built up from the sensations derived from both retinae.

What is to be said in favour of the "Natavistic" theory ? The very construction of the retina - the fact that each element is sensitive and that it is extended, would imply that previously formed muscular impressions are not necessary to give us an idea of the extent and relation of the various objects. And, again, it is difficult to see, how, unless there is something native to the mind the impressions of light and color can combine with those derived from the other senses, as we know they do, to enable us to form a judgment. At any rate the reference of the object to a position in space, and the laws which regulate the process of perception must be native to the mind, but the process by which after childhood we are able to distinguish a complex object in space, can only be empiristic in origin. The question may be left here,, for as it is impossible to derive any information from the child, it is equally impossible to prove experimentally that the perceptions of the closed and motionless eyes, is the result of past sensations derived through the muscular sense without any assistance from some native activity of the mind.

In order that a perception of any object may be produced, we must presuppose that the mind is active, and can re-act upon the stimuli sent along the optic nerve; and in order that it may have space form, the mind must be capable of combining the sensations derived from the visual centres, with those derived from other senses. There must be a synthetic power of the mind. When we look at a colored surface, we have a perception of color by the eye alone, but in order that it may have any relation to surrounding objects the mind must synthesize the stimuli with those derived from other channels. The very difference in the quality of the sensations from other channels would show us with which kind the mind would most probably combine in producing "Space form". Those from the nose, & tongue, have exceedingly imperfect spatial qualities, they are incapable of being arranged in a definite series, those from the skin, muscles, and ear have spatial qualities, and it is the sensations derived from these channels that the mind combines, with the stimuli derived from the retina.

We have now to discuss the question of "Visual Judgment." It has been incidentally mentioned in the previous remarks upon perception, that in order to form a correct visual judgment, the mind must call upon its previous experience, and make use of secondary helps derived from the other senses. We can show what these secondary helps are; we can tell the laws according to which the mind associates them, but we afterwards come to a full stop. It has not been given to us to correctly estimate and interpret the inward workings of the mind.

Our correctness of visual judgment depends, -

1. Upon the distinctness of the visual perception, and this depends upon the distinctness of the retinal image.

2. Our previously estimated experience.

3. Secondary helps, which may be divided into,

(a) Sensations derived from the other senses, but principally tactile sensations.

(b) Sensations derived through the muscular sense, both from the general muscular system and the special muscles of the eye.

4. The amount of attention given.

Let us now treat of these in detail and show their value.

TACTILE SENSATIONS.

The acuteness of the sensations of touch varies in different parts of the body, the tip of the tongue being the most acute and the skin of the middle of the back, being the least acute. The acuteness varies in different people, but the relations of the various sensitive areas remain the same, unless we cultivate the various parts, when the sense of locality may be rendered more accurate.

Blind people, in time, acquire a remarkable degree of delicacy of feeling, by cultivating the tactile sensations derived from the tips of the fingers, but even with the very best training they never acquire that amount of delicacy which is imparted by the use of the eye and hand together. The eye is the leader, the eye is the critic; it can move quicker, its judgment is more delicate, whereas touch is slower and less delicate. That this is so, can be easily shown by blindfolding the eyes, and then attempting to describe the size and peculiarities of various objects. From our first estimation of judgment, the eye leads the hand, for the eye has already explored all the parts of the body open to its inspection, long before the field of touch has been constructed. The tactile sensations however give the eye a standard to work upon in forming a correct judgment of the size of objects. The hands can move over all parts pf the body and touch all objects within reach. The eye observes the hand, and compares its size with the other parts of the body, and the various objects with which it is brought in contact. The mind stores up these observations and applies them when necessary to estimate the magnitude of objects.

Tactile sensations also assist us in forming a correct judgment of the distance of objects. The eye has already formed a correct estimate of the length of the arm, and of the length of the body. In the erect posture the hand can touch all objects within its reach around the upper part of the body, the feet can touch all those in the lower part of the field of vision. We are familiar with the ground upon which we tread, we experience a different sensation when walking over a carpet, and although the tactile sensations are not so acute nor the range of movement so great as in the case of the hand, we are able to appreciate very delicate shades of feeling. Jastrow's experiments in this connection are very interesting. The idea was to compare the judgments derived from the eye, hand, and arm, as regards the distance of objects. One sense was to receive a clear perception of an object, and then express the distance of it from the body. It was found that the eye under-estimated small distances and over-estimated large distances. At a distance of 38 m.m., no error was made. The hand, however, over-estimated small and under-estimated large distances except at 50 m.m., when the estimation was correct, whereas the arm over-estimated all distances.

Again, when one sense received the impression and the other sense expressed it, it was found that if the eye was the expressing sense, the length was greatly under-estimated, whereas if the hand was the expressing sense, the length was greatly exaggerated. In the case of the arm, it was found that if it expressed the result received by the eye, the length was over-estimated, but if it expressed the result received by the hand, the distance was under-estimated. The law of habit would reconcile and explain these facts. The receiving sense is correct, the expressing sense is in error and it either over or under-estimates the distance according as it approaches an estimate, whose accuracy is known by the particular sense. The accuracy of the three senses was found to be in order, eye, hand, and arm, although there was comparatively little difference between the two last.

It has been already mentioned that the eye, skin and muscles form an extended series of sensations which are capable of readily combining together. It has been shown how the visual and the tactile combine, we have now to show the relation between the tactile and the muscular sensations. In the before mentioned experiments, the muscular sense is brought into action through the specific sensations derived from the nerve apparatus, which forms the end organs found in muscular fibre. The quality of the muscular sensations varies,

(1) According to the muscle or series of muscles brought into action.

(2) According to the tactile sensations derived from the skin by the alternate contracting and relaxing of the muscles, e.g. if we flex one arm and rotate the other the derived sensations are immensely different.

But the muscular sense also assists the tactile by discriminating the amount of pressure which is brought to bear upon the skin The sensations derived, from pressing a piece of wood hard & from gently touching its surface are entirely different.

It also assists tactile sensations to fix the position in space of any object according to the number of muscles brought into action to reach it & also according to the different actions of these muscles

In a blind person it is impossible to tell what value should be attached to the muscular sensations and the tactile sensations in estimating the size position, &c., of objects but it is probable that the greater part is due to the muscular sense.

At any rate the different sensations derived from the eye, hand, and muscle readily combine in early life to form a standard.

So indissolubly are muscular sensations and true tactile sensations combined, that in every day language we speak of knowing a thing by touch when we are really employing both senses.

The visual and the tactile sensations differ however in one important point. We know that excessive pressure applied to the skin gives a sensation of pain. We have no evidence however, that excessive stimulation of the retina causes a like sensation. It is perfectly true that if we look at the sun we have a blinding painful sensation, but this is not produced by impulses travelling along the optic nerve but along the other sensory nerves of the eyeball and its appendages. So also when we cut the optic nerve in enucleation of the eye there is no more pain than can be accounted for, by dividing the sensory fibres in the sheath of the optic nerve.

There is this agreement however, between them, that both visual and tactile phantoms may be produced by stimulation of the central nervous system. But the tactile phantoms are rudimentary compared with the ocular, because the skin is so much slower in appreciation than the eye. The study of ocular phantoms - something which we cannot recognise by touch - shows how much we are dependent in every-day life upon tactile sensations. Our conception of them is uncertain. The experience derived from the previous sensations of touch being absent, the imagination has very much less to work upon and must reason it out, although very inadequately by other channels.

Although the eye leads the hand in the great majority of our daily experiences, in some cases the tactile sensations are more advantageous than the ocular, e.g. the violinist could never produce the same purity in the notes, if he regulated the strings by the eye alone.

Taking it for granted that both tactile (meaning true tactile and muscular) sensations and ocular sensations are formed in the mind, we are now met with the question, how does the imagination make use of them ? Is there a true synthesis or is there merely a combination ? The latter is undoubtedly the correct answer. Sensations of touch can only synthesize with those of touch, those of the eye with those of the eye. When walking along a road with the eyes fixed upward, the mind can tell us how the road would look, by means of the sensations of touch alone, and similarly if we are in a carriage the mind can tell us through the visual sensations how walking on the road or grass would feel. If we had the sense of sight alone, we would form a different conception of the world, and similarly if we had the sense of touch alone, everything would appear different. We cannot illustrate the former, but the case of the congenitally blind in whom vision has been restored illustrates the latter. At first they find great difficulty in combining their visual sensations with those previously arrived at from the sense of touch.

The point to remember is, that eye and touch sensations do not become inseparably combined, but are merely united by the mind to form an image or idea of the object.

MUSCULAR SENSATIONS. We have already mentioned that these have spatial qualities and combine readily with those of light and color as we have already shown they do with touch.

(a) Muscular sensations from one eye only.

In order to produce a clear perception there must be a distinct retinal image, and in order that a distinct retinal image may be formed, it must fall upon the most sensitive part of the retina, the macular region, and in order that this may take place always, there must be movement of the ocular muscles and consequently muscular sensations. The eye constantly changes its point of regard by various movements round a fixed point, which is situated $1\frac{1}{2}$ m.m. behind the geometric centre. It can do so by the action of six muscles which are specially relegated for this purpose.

In monocular vision, we have also to consider the muscular sensations derived from action of the ciliary muscle in the process of accommodation. If we fix our eye upon an object near at hand we are conscious of a strain, and by constant observation of the presence or absence of this sensation we can easily tell whether an object is near at hand or far away.

If we attempt to determine the distance of an object from the eye, by the sensations derived from accommodation alone we are subject to many fallacies. Although it is an important help to us in forming visual judgments, it is necessary to call up or bring into action other data in order to form a correct conclusion.

(b) Muscular sensations derived from movements of both eyes and Binocular Vision. It is best to consider these together.

That we do have binocular vision can be easily proved. If we hold two figures in front of the eye at a distance apart from one another, we find that the finger nearest the eye appears double if the eyes are fixed upon the most distant one; and that if the eyes are fixed upon the near finger, the more distant one appears double. The double images will also be found to belong one to one eye and the other to the other.

Again in cases of paralysis of one or more of the ocular muscles of one eye, the most disagreeable system to the patient is the Diplopia, proving that previous vision was binocular.

We can easily produce Diplopia, in ourselves, by pressing one eye in various directions. Any object looked at appears double, and it is easily recognised that the indistinct image is formed by that eye, whose visual axis has been altered.

The rays of light proceeding from the greater part of the objective field of sight affect both retinae, but a part of the field to the right affects only the right eye and a part to the left, the left eye.

To prove this, hold a pencil above the right shoulder so that it is invisible. Gradually move it forward till it is seen. If we now close the right eye it is invisible and it is only when it is brought far forward that it is observed by the left eye. This is due to the conformation of the face, the nose especially cutting off the rays of light.

Images must fall in binocular vision upon two parts of the retina, which are so related to one another, that the resultant effect is a single object. Points of the retina so related are called <u>corresponding points</u>.

The anatomical examination of the retina shows us that these corresponding points cannot be identical over its whole surface, for if we were to superimpose one retina on the other we would find that the entrance of the optic nerve was to the left of the central point in the right eye, and to the right in the left eye. But if we examine the retina physiologically, by the resulting effect produced by stimulation with rays of light we find that the right half of one eye corresponds to the right of the other eye, i.e., the nasal side of the left to the temporal side of the right, the left half of one to the left half of the other, and also that the upper and lower parts of each retina also correspond. When the eyes converge for near objects we not only have accommodation but also contraction of the pupil cutting off some of the rays of light. The visual fields of the two eyes, in convergence are shown in Figure VI.

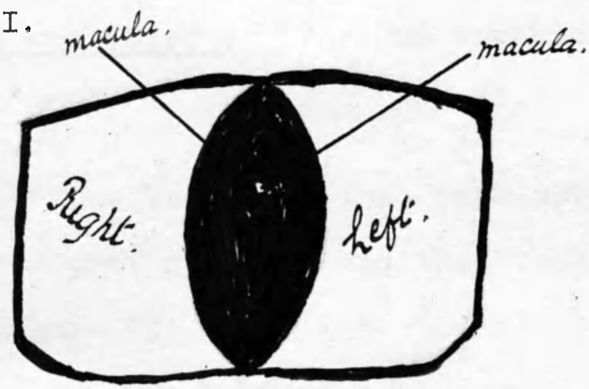


FIGURE VI.

All rays of light falling upon the shaded part are seen as single by binocular vision, on the unshaded part by each eye separately. In speaking of perception, we showed how the mind treated those sensations derived; from the regions at a distance from the macula.

The eyeball is moved by six muscles in various directions, but there are certain limits which cannot be exceeded, and these limitations are so arranged that binocular vision can always be effected.

We can converge the eyes for near objects, the two eyes working in harmony by moving inwards to the same extent. They also work in harmony in an upward and downward movement.

We cannot cause the eyes to diverge, however, without great strain, as in some spectroscopic examinations. If we could cause them to diverge binocular vision would be impossible as corresponding points of the retina would not be affected and objects would appear double. How is it that if two images are formed, we only perceive one object? Various theories have been formed to explain it.

(a) One theory is that both optic nerves contain exactly the same amount of fibres and that they unite in the brain as shown in the Figure VII.

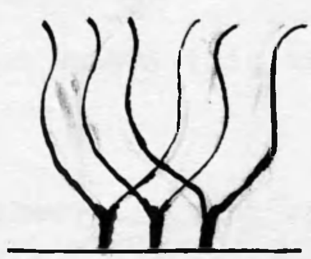


FIGURE VII.

But no account is taken of the decussation of the fibres at the commissure, and everything points to the fact that nature provides this decussation in order that we may enjoy binocular vision.

(b) Figure VIII serves to explain another theory.

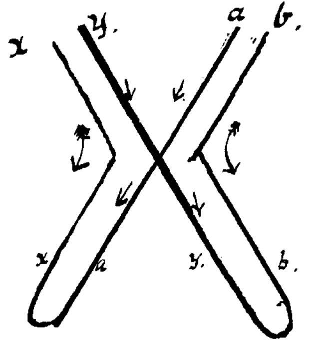


FIGURE VIII.

There are four fibres shown; two decussate y, and a, two do not decussate, x and b. The fibres x and a coming from corresponding points of the retina are united at the commissure into one nerve. In the brain these two fibres are either connected by a loop or spring from the same point. So also with the fibres y & b That is to say, that the fibres from the left half of each retina are situated in the left hemisphere of the brain and those from the right half of the retina in the right hemisphere. There must therefore be some uniting loops to connect the two optic centres in the brain and it is thought that the commissural fibres of the corpus callosum supply this, and so explain the unity of action of both sides.

Another theory is that vision is monocular, and that by motion of the eyes, the double images are alternately combined and separated, the mind interpreting this so they we see single.

Followers of this theory point to the fact of how difficult it is to keep the eyes perfectly still. It is impossible to hold one of the muscae volitantes perfectly steady even with the very greatest care. But how can we reconcile this idea with the fact that two stereoscopic pictures can be seen as one, when lighted by an electric spark (the duration of which is infinitely less than the movement of the eyes).

There is no doubt that experience plays a very large part in our perception of the singleness of objects, independently of the images falling upon corresponding parts. In a case of central opacity of the cornea of one eye, the images cannot fall upon corresponding points, but the object is seen as single by both eyes, acting together. Again in cases in which an artificial pupil has been made in one eye, there is no diplopia although the optical axes of the two eyes are not equally directed to the object. In a case of strabismus in which diplopia has been manifest, objects are after a time observed as single, and if the optical axes be again equally directed to the object so that the images fall upon corresponding points, as can be done by an operation on the offending muscle, double vision will be at first complained of.

All these facts point to the conclusion that however necessary it is for the images to be formed on corresponding points in early life, there does not exist the same necessity after the experience has once been acquired. In fact the question has been asked whether if singleness of vision can supersede a temporary diplopia the whole question of binocular vision may not be got rid of by saying that it is a gradually acquired experience. At any rate, observation of the child shows that the convergence of the eyes upon objects is not nearly so exact at first as it becomes later on and it is thought, that, although it sees objects as double at first, it gradually acquires the power of seeing single, and that the future perception of singleness is the result of previously acquired experience.

We have already mentioned the relation between the muscular and tactile sensations. We have now to look at the relations between the muscular and the visual sensations. Here again the eye is the leader; all the various movements of the eye are dependent upon visual sensations. Whenever we move the eyes we look for an object; when we converge the eyes we look for an object near at hand, when we move the eyes downward we look for an object in the lower part of the field, and so on, every movement of the eyes being determined by visual sensations, in order that two images of the object observed may be formed on corresponding points of each retina, so as to be observed as single.

The sum of all the points seen as single, i.e., which fall on corresponding points of each retina, when the point of regard remains the same is called the Horopter and if we study the horopters with reference to the different limitations of the movements of the eye, we see how wisely nature has provided for us, e.g., with the head erect and looking into space, the ground is the plane of the horopter. It would be awkward to say the least of it, if objects on the ground in this position of the eyes, were observed as double.

What are the advantages of binocular vision ? If we were limited to the use of one eye all our presentations of sense would be different. It is no criterion to go upon, to say that when we close one eye and look at objects with the other, everything is observed almost as well as with both eyes. We are then making use of the experience derived from action of both eyes. If this experience be arrested, we can tell very little of the distance apart of two objects situated far away from the eye. Even with the advantage derived from experience, we are liable to grave errors regarding distance and position of objects with one eye alone. Wundt found that if he attempted to estimate the distance of a black thread on a white background with one eye, he found great difficulty in coming to anything like a correct conclusion, and it was only when the thread was brought much nearer, (so that the muscular sensations derived from accommodation could be utilized), that any degree of accuracy was obtained.

The spectroscope forms a capital illustration of the advantages derived from binocular vision. Two pictures are photographed by means of two camera lenses (the rays of light being then parallel) placed close together. It will be seen that they are not both alike, for the photograph obtained by the right lens shows objects more round to the right, and that from the left lens more round to the left. These are the pictures which would be obtained by each eye looking separately at a distance. On looking through the prismatic lenses of the stereoscope however, they are seen as single and much more in detail.

How closely the two eyes are united physiologically may be shown in cases of sympathetic opthalmia in which after injury to one eye, disorganization often sets up in the other, unless the injured eye be enucleated.

We will have more to say of the advantages derived from binocular vision when we come to speak of how our estimate of size, distance, solidity &c., of objects is formed.

Experience. The ultimate results derived from stimulation of the optic nerve are formed in the brain, and, therefore when we make use of our experience, we are calling up a psychical force. This being so, we would expect that, in various pathologies of the mind, our previously formed perceptions and judgments would play no small part in the symptomatology of disease. And it is so. A person suffering from Delirium Tremens associates what he imagines he perceives, with the things he has been accustomed to see in daily life, and the lunatic whose habits were miserly, may be constantly counting his gold, imagining that any of the smaller articles in his surroundings are the pure metal.

Even in health the influence of experience may lead us to form either a right or a wrong judgment. When walking along a country road at night, we may be suddenly arrested by perceiving what we imagine to be some one blocking the way, leaning against a tree or crouching in the road side, and it is only by calling up our experience that we are enabled to associate it with some chance combination of shade or color, and arrive at a correct judgment.

Similarly our experience may lead us astray. We imagine that a light we see in a window at night is at a certain distance, whereas in reality it may be much nearer or much farther away.

We have already given some examples of what great advantages we derive from experience in the formation of visual judgments. In fact, the mind judges objects according to the way it has previously been accustomed to judge of the same or similar objects. If we therefore vary the usual interpretations derived from experience, our judgment is liable to be vastly altered, as the mind cannot associate the impressions derived from the other senses, with those which the eye bringsto bear upon them. If we turn a chair upside down, we cannot judge of it in this position with the same exactitude, as when it occupies its normal situation. So also when we turn a book or a photograph upside down, we disturb the relationship derived from experience with the sensations now formed. It is experience, again, which makes us proficient in our professional attainments and in the various sciences and arts.

The influence of Attention has been already fairly well dealt with under the heading of perception. It only now remains to say, that attention and experience work hand in hand. If we fix the attention the impressions derived from experience are much more correct, if we relax the attention, as when sinking into sleep, the conclusions derived from experience may be false. It only needs a few moments, however, of fixation of attention to dispel all the wrong ideas which may be formed. During sleep, when the attention is arrested, the interpretations of experience may run wild, we may see objects which strongly excited the mind during the day on an entirely different basis, it may be more grotesque, more pleasant or more fearful, but the moment we awaken and fix the attention we judge of it all as merely a dream.

But experience and attention act together in another way, for it is possible for us to regulate our choice of what we will see. We can limit the size of our field of vision and see objects situated in it, either distinctly or indistinctly, according to the degree of attention directed to bear upon them, or we can give a few lines drawn by an artist, or a complicated geometrical figure two or three different interpretations according to the manner we direct the attention.

It is a common experience to find a person who is busily engaged in conversation unable to tell the time to another person immediately after consulting his watch. He will most likely need to have resource again to his watch before he can give an answer. But an undercurrent of thought may be going on in his cerebrum so that he can tell hours afterwards the exact time when he last consulted it, even although it was imperfectly registered on the mind at the time, through the attention being engrossed by some other subject. These undercurrents of thought are always going on. We may forget the name of a street, a sentence, or quotation, and suddenly remember it hours afterwards when the attention is engaged upon an entirely different subject. In fact, if we have forgotten anything which has been once carefully registered and which we cannot for the moment recal it is often better to let the question settle itself by fixing the attention on some other subject.

ESTIMATION OF SIZE AND DISTANCE. It is difficult to separate these, for it is by means of our estimate of the distance that we judge of the size of an object, and vice versa, from the size that we judge of the distance.

The apparent size must be kept distinct from the real size. The latter is a comparison of the size of the object with a certain known standard already fixed in the mind as the result of experience, derived from combined tactile and visual sensations. The apparent size depends upon the size of the visual angle, - upon the size of the image formed upon the retina - and is therefore a mere fraction of the size of the object as we perceive it. The retina is a fixed standard; the imagination associates the impulses received from the affected part of the retina with a certain known size derived from the other senses and experience, which size, bears a relation to the whole retina or the whole field of vision. The real size is therefore judged of through the apparent size, i.e. through the size of the visual angle, and for this reason, the nearer an object is, the larger it appears, and the distance is judged of as being less than if the object appear smaller. When we stand between the rails of a long straight railway tract we can judge accurately of the size and distance apart of those rails near to the eye, but, as we recede the rails become smaller and the distance separating appears less and less till they ultimately seem to converge. The visual angle has become smaller and smaller as the object has receded from the eye. For the same reason the houses of a long street seem to become smaller at a distance and to approach one another.

But when we come to estimate the size and distance of objects far away, the mind has no data to go upon, at any rate no exactly known standard for comparison. At about 40 feet from the eye the rays of light become parallel and no accommodation is necessary to see an object plainly in an emmetropic eye. The mind then loses all the data derived from the contraction of the ciliary muscle, and the other muscular sensations are infinitely small, compared with those derived from the observation of near objects. Tactile and muscular sensations being absent and no fixed standard of any value being formed, as the result of experience, it is not surprising that our estimate of the size and distance of far away objects may be greatly at fault. By the eye we have no idea of the sun being 91,000,000 miles away from us, and of the stars being many millions more.

We judge of them all as at practically the same distance. Our estimate of the size of distant objects is at variance with what we know by other methods to be the real size and principally depends upon the intensity of the luminosity.

There is also great variation in the size of distant objects as estimated by different people: to some the moon appears to be the size of a crown piece, to others a plate, to others a small bicycle wheel, and to some even the size of a cart wheel.

But the apparent size of an image does not depend alone upon the real size and the distance away from the eye: it also depends upon whether the accommodation is brought to play or is relaxed. For near objects, therefore, the mind also gets the assistance derived from muscular sensations. The stronger we accommodate, the nearer we judge the object to be, but if there are no sensations derived from contraction of the ciliary muscle, we judge of the object as being more distant. The number and variation of the sensations derived from the proper ocular muscles, apart from accommodation, gives us a good idea of the size of an object at a moderate distance, for, if the eye has to be moved over a wider area before the whole of the object is seen we judge of it as being larger, than if an exact image of it all, is formed with a very little contraction. The great value derived from muscular sensations can thus be easily appreciated. With one eye alone, we are able to arrive at a fairly accurate conclusion regarding size and distance by means of accommodation alone, but in this case little or no assistance is derived from the proper ocular muscles, and the range of accommodation being limited we are liable to commit many mistakes, especially in any fine work as e.g. threading a needle. Even with both eyes, much greater accuracy in our estimate of distance is ensured, if other objects be interposed between the eye and the object observed. When at sea, we find a great difficulty in estimating the distance between our ship and another at a distance from us, and even with long experience there is a great variation in the distance as computed by different observers. If however it were possible to moor boats between the two ships, our estimate would not be far wrong as we would judge of the distance between each boat, and, by a mental process arrive at a fairly accurate estimate of the whole distance. Everybody knows how difficult it is to estimate the width of a broad river with any accuracy, but if it be spanned by a bridge, we judge of the distance between the arches, and by an arithmetical process, add the various results to obtain a correct conclusion.

Even with smaller distances we are liable to error

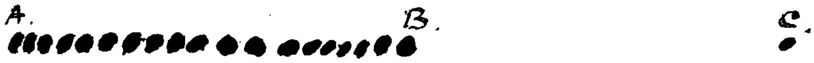


FIG., IX.

In Figure 9 the distance between A. and B. appears greater than the distance between B. and C. although by measurement they are exactly the same.

The condition of the atmosphere, plays an important part in our estimation of size and distance. All distant objects appear dim to us, on account of the amount of atmosphere the rays have to pass through before they reach the eye: therefore in a fog where objects appear dim, they are judged of, as being farther away, and being further away, we judge of them as larger. Our judgment is at fault, we have overestimated the distance. Similarly if the atmosphere is clear as e.g. on some exceptional days in this country, distant objects appear larger than they really are. We have again overestimated the distance. Our estimate of the size and distance of objects seems to be a fixed quantity according to the country in which we live and we cannot suddenly make allowance for changes in the condition of the atmosphere. Canadian * volunteers take some time before they become accustomed to the distance and size

* Since the above was written a member of the Canadian team has won the Queen's prize at Bisley.

of the target as estimated in our atmosphere and our troops abroad, have to make allowances for the clearness of the atmosphere in the various countries in which they are stationed, or with which they are at war.

For the same reason the sun at sunset, appears larger than the sun in mid heaven, although here we also have the interposition of various known terrestrial objects of a fixed size between us and the horizon to guide us. How much of the increase in size may be due to the indistinctness of the atmosphere in the evening, and how much to the comparison drawn between its size and that of known objects which intervene between us and the horizon, it is difficult to say, but most probably the presence of known data play the most important part. When we see the sun setting behind a large tree and com-completely filling it, we judge of its size with reference to the size of the known object.

The arrangement of the light and the direction of the shadows, causes a variation in our estimate of size and distance. In the morning and evening when the light is obscure and the shadows lengthened, objects are judged of as being more distant than at mid-day.

That distance and size react upon one another may be well shown by looking through the wrong end of a pair of field glasses. All objects appear small, and we therefore judge of them as being at a great distance.

Again, at a magic lantern entertainment if the eyes have been fixed upon the screen for some time at pictures of a certain size, we instinctively judge of the distance of the screen from us. If, however the image be increased in size, the screen seems to move closer to us.

We now see how our estimate of size and distance is built up: how it depends upon the size of the visual angle, the different positions of the eye, the amount of light and direction of shadows, the condition of the atmosphere and the standard derived from previous experience &c., and how any variation in any of these cause a variation in our estimate.

But the intensity of the various sensations, and the time during which they last, may also cause variations in our estimate of size and distance. The differences in the intensity of the sensations, as we would natuarlly expect, are best shown in the case of the visual and muscular spatial series.

In a dull light objects are liable to be judged of as being larger than they really are, whereas in a bright full light, nicer discriminations can be effected.

It would also seem as if a certain standard was excited in the mind, by the intensity of the sensation derived from the amount of energy expended in each movement of the eye by the proper ocular muscles, and that if more energy be expended as e.g. in a case of incomplete paralysis or in a series of muscles tired out from some other cause the intensity of the sensation is greater and the object appears larger. If the external rectus be partially paralysed, objects appear to be situated "where they would have been if the same intensity of sensation had been necessary to bring them to this position with a normal function of the muscles." The patient in such a case will not only imagine objects to be larger than they really are but also at a greater distance from the centre, on the paralysed side, than is in reality the case.

The time during which the sensations last, has an important influence in determining the size. The longer it takes for the muscular movements of the eye to bring the various parts of an object on the macula, the greater the object is judged to be.

Whenever we look at a series of objects at a moderate distance from us, the mind instinctively grasps the size of an object and the distance separating two objects as a standard with which to compare the size and distance of everything within sight.

But if the field be unbroken e.g. continual moorland or a continual area of unbroken snow, or if the standard be often repeated as in the movements of bodies of soldiers, there being no details for the mind to work upon, it imagines them as of greater extent than they really are.

The laws by which we estimate size and distance are psychological, the mind using all the data above given, becomes more and more proficient, till very small differences can be correctly appreciated. It is to the spatial series of sensations derived from the retina and the muscles, that we naturally look for the smallest differences. How much the mind makes use of each it is difficult to say, some observers imagining that the muscular sensations are the principal help, others denying any assistance from the muscular sensations and claiming all for the retinal series. Weber has shown that a distinct muscular sensation is caused by moving the fovea the $\frac{1}{520}$ of a Parisian line and Helmholtz has shown that the $\frac{1}{250}$ m.m. variation in the position of an object can be detected. This would seem to show that both the local retinal signs and the muscular sensations play the principal part when acting together, in discriminating small differences in the size and distance of objects and it is most probable that these are the sensations cultivated, when skill is acquired.

If two right angled triangles be drawn, and one of them filled up by means of various lines drawn from the angle, the divided triangle appears larger than the undivided one, and if a segment of a circle be drawn so as to intersect these lines the appearance of magnification is still greater.

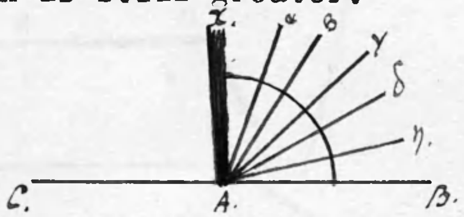


Fig: 10

The triangle X.A.B. appears greater than the triangle X.A.C.

Again, if a series of lines be drawn horizontally so as to form a square they appear higher than a series of the same lines placed vertically.

Fig: 11

X. appears higher than Y. and Y. appears broader than X although each line is exactly an inch in length.

Even with the previously mentioned data the mind is liable to error. A few lines drawn upon a piece of paper give a deceptive appearance according to the mathematical perspective of the lines and angles.

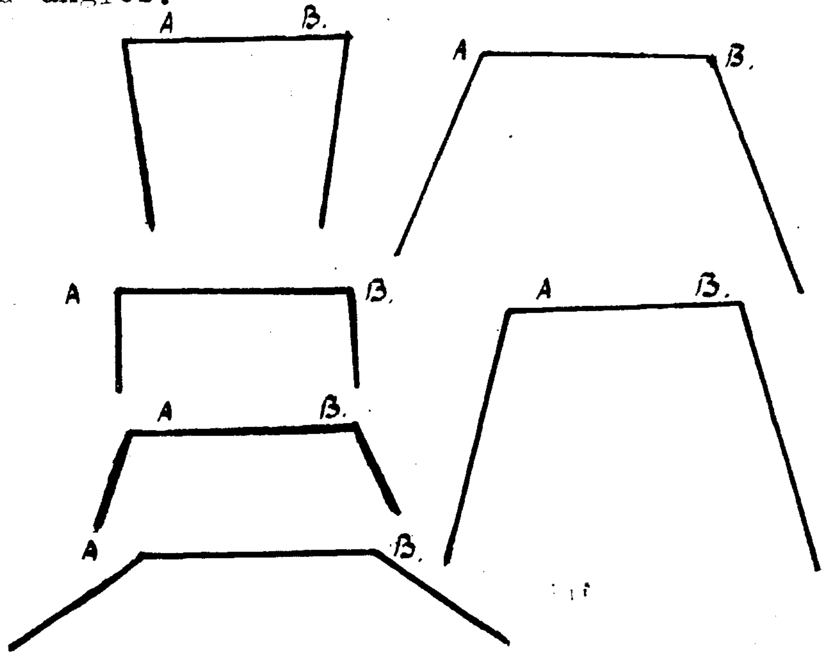
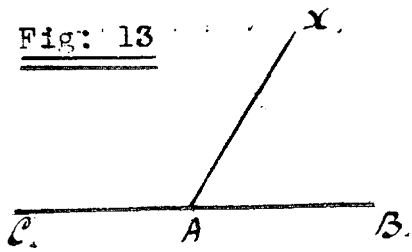


Fig: 12

In Figure 12 the lines A.B. are all of the same length although they appear to vary.

An acute angle appears larger than it really is. The angle X.A.B. is 60° but the obtuse angle X.A.C does not appear to be twice the size of X.A.B.

Fig: 13



It is for these reasons that short people affect dresses with the stripes horizontal, so as to give themselves an apparent increase in height, and thin people have their dresses striped vertically so as to make themselves appear stouter.

Again a vertical line appears longer than a horizontal one of the same size.

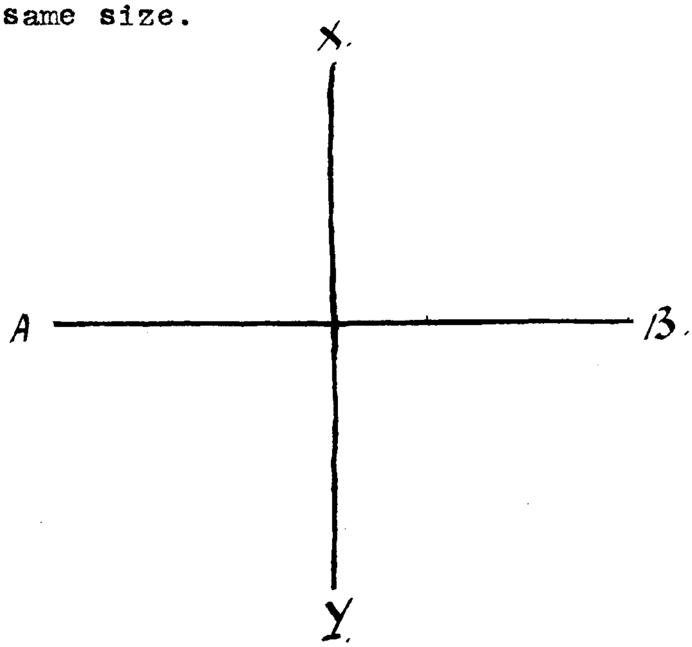


Fig: 14

I have drawn the line A.B. three inches in length with the aid of a ruler. When I proceed to draw a vertical one of the same length I find that the result X.Y. is nearly ¼ inch shorter than A.B. although they appear to me to be exactly the same size.

Objects in the upper part of the field of vision are liable to be exaggerated.

B. H. K. S. 8.

Fig: 15

The upper and lower halves of the letters B.H.K.S. and the figure 8 appear to be of the same size, but if this page be inverted it will be found that the upper half is to all appearance the larger.

<u>ESTIMATION OF DIRECTION.</u> It is to be remembered that the retina is curved with the concavity looking forwards. If we look at an extended straight object at a distance from the eye, it will appear slightly curved. The accommodation is relaxed and the rays of light are parallel. On bringing the object nearer to the eye the pupil contracts, cutting off a number of the rays, so that it cannot be seen as a whole at one time. In order to estimate its direction the eye "runs" over it so that different images are formed on the retina; the mind pieces the component parts together with reference to each other so that we can estimate it as a whole, and in its real direction. There must be no movement of the head; the same ocular muscles must be brought into play, in order that the continuous parts may form images upon the same parts of the retina. When the mind refers them to the exterior, the relations between those parts which fall upon the

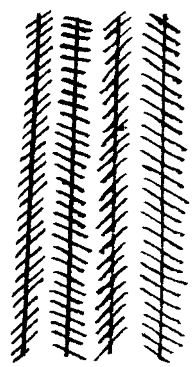
same parts of the retina remain the same.

When an image falls on a part of the retina at a distance from the macula, we estimate its direction, by the relation it bears to the ray or series of rays, which affect the retina in the visual axis.

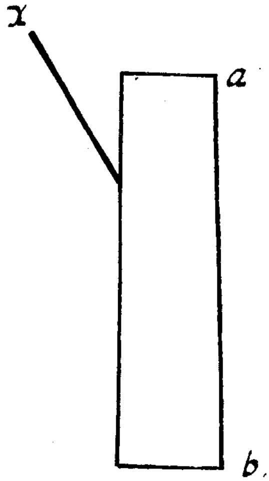
If the head is moved or if one or more of the ocular muscles is brought into action in excess of the others, the muscular sense enables us to form a true conception of the direction of the observed object.

Still we are liable to err

Fig: 16



The four vertical lines A, B, C, D. were drawn exactly parallel, yet by looking straight at them, and more so if we look at them obliquely, they appear to diverge and converge. The direction of the cross lines affects our perception of the distance between them. By a strong effort of the will it is possible to see them as they really are, and if the cross lines be disregarded as by holding the page horizontally on a level with the eye the lines are at once seen as parallel.



Again the point of emergence of the line X on the line a.b. can easily be placed at three or four different points by the same number of observers.

ESTIMATION OF FORM. The visual images formed at the time of observation, only play an inferior part in enabling us to estimate the form of objects. The eye can only make out colour, light and shade. We are principally indebted to the association of ideas derived from the other senses, and particularly from those of touch. A person with congenital cataract in which the lens has been successfully removed, cannot appreciate the fine peculiarities of cube or sphere. Everything appears to him at first as if situated on a flat surface and it is only by a process of training, and especially of his tactual sensations in relation to those derived from the eye that a correct conclusion is arrived at. With monocular vision the retina is only affected by the rays coming from one side of the cube and we can only tell the condition of the other parts by calling up our previously formed sensations or by changing our position so as to bring other parts upon the retina, leaving it to the mind to place the two parts in their exact relation.

In normal vision we have the assistance derived from the two eyes acting simultaneously, two different views of the object looked at being fused by the imagination into one. The image and consequently the perception derived from one eye is not exactly equivalent to that derived from the other eye. This is illustrated by the stereoscope where an appreciable difference can be seen between the two pictures. By the aid of prismatic lenses in the case of the stereoscope we are enabled to see only one picture and much more in detail: in the case of the eye the decussation of the fibres of the optic nerve at the commissure no doubt plays an important part.

When the attention is fixed upon an object, that part lying in the visual axis is clear and well defined compared with the surrounding parts. It would seem that this depends upon the number of cones affected.

We know that the fovea consists principally of cones and it is on this part that the image is formed, when the eyes are directed straight at an object. The diameter of a cone is 3 M. and it has been found that in order to see the images of two points on the retina they must be 3 M. apart. As we recede from the yellow spot the distance betwen the cones becomes greater and two points lying at a greater distance than 3 M. may be seen only as one.

ESTIMATION OF MOVEMENT:- An object is judged of as being at rest, when the image of the object does not change its position on the retina when our own eyes are stationary.

When the object is in motion, we have to consider the relation of our eyes to the object, and of the object to our eyes in any discussion of the method of our estimation. If our eyes are at rest and looking straight ahead we judge of the movement of an object by the movement of the images over the retinal surface and the different sensations thereby excited. It will however after a time pass out of our field of vision and be unrecognisable. The continuous areas of the retina are excited successively by images which are similar and we judge of it as being the same object.

If however we move the eyes so that a clear impression of the object always falls upon the macula, we know that the object is moving by the sensations communicated through the muscular sense from the action of the proper ocular muscles. If the head be perfectly stationary during this time, the object after a time passes out of our field of vision. If the head be moved, the sensations derived from the contraction of the muscles of the neck and the tactual sensations derived from the skin inform us how far the head has moved from the position from which it started. If the object be moving in a circle, we have ultimately to move our body to follow it when the mind gets the advantage of an enormous amount of data through the muscular sense to form a correct estimate. If we have the advantage of all these data our judgment of the direction and rate of motion will be fairly accurate: errors are most likely to crop up when the eyes and the body are at rest as the mind then loses the muscular and tactual sensations.

It is also possible to see motion, when the eyes and the object are both motionless. If the same areas of the retina are excited by images which are dissimilar the object is judged of as moving. It is for this reason that the coloured points of the retina's own light seen to be in constant motion when the eyes are closed and stationary. When the object is stationary, and the muscles of the eye are in action we judge of the object being at rest, as the sensations derived through the muscular sense, correspond to the movement of the images over the surface of the retina. Past experience also greatly assists us. It is for this reason, that, when we are reading, we judge of the letters as being stationary even with contraction of the ocular muscles. The same remarks apply to all stationary objects of a large size, in which it is necessary to move the eyeball in order to get a proper appreciation of it as a whole.

In disease, however, with the eye at rest a stationary object may appear to move e.g. in vertigo and certain brain disorders.

In some cases the motion can only be apparent as e.g. when seated in a ship's cabin during a voyage. A large number of different sensations and previously formed associated ideas principally derived through the muscular sense, assist us in forming a correct judgment. On the ship's deck it is much easier, as we have the assistance of visual impressions in addition to the other data.

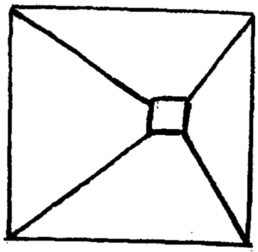
Our judgement of motion is liable to error. It is found that we overestimate the speed of small objects and underestimate that of large ones. This is possibly the fault of past experience.

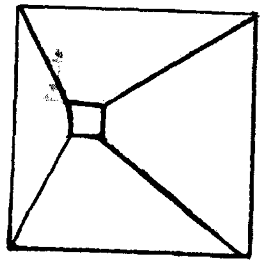
We are more accustomed to a quicker movement where small bodies are concerned. Again if we look at a waterfall at a distance, or at a continual stream of water from a can, we may judge of it as being at rest after a time.

The explanation of this has been attempted on the principle of fatigue, but it is more probably due to some law of cerebral activity with which we are unacquainted, for the same elements of the retina, when excited simultaneously, have been found to give rise to impressions both of motion and rest.

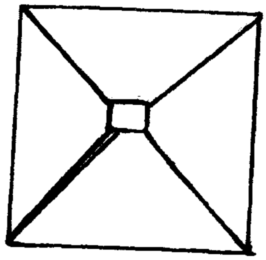
ESTIMATION OF SOLIDITY. The point underlying the discussion of the formation of our estimate of solidity is this, that if we look at a solid object with one eye, we get a different impression of it with the right and left eye. The parts of the retina which receive the impressions do not correspond, but by a mental act we analyse these impressions and have a perception of only one object which we judge of as being solid. In all cases in which the imagination combines two dissimilar images into one projection, we know that we are dealing with a solid object.

L





R.



X

L = Image as seen by the left eye.

R = " " " " " right eye.

X = Image seen stereoscopically.

It has been supposed that our judgment of solidity is not so much as psychical act as has been supposed, but that it was due to a rapid movement of the eyes so that the same objective image fell upon corresponding parts of the retina. How this has been disproved by the aid of an electric spark, which is practically instantaneous, has been already shown. We have also already shown by the stereoscope how the two dissimilar objects were combined as one.

The amount of light reflected from the surface of an object, is an important factor in our estimation of its solidity. The parts which are raised, cast shadows upon the depressed parts and we therefore recognise the elevated parts more plainly than those which are deeper. That it is the shadows, which enable us to recognise the depressed parts from those which are elevated, can be shown by an arrangement of mirrors, when those parts which we know are raised can be seen as depressed and vice versa.

To distinguish the finer peculiarities of a rough solid body, it must be placed at a moderate distance from the eye, so that the muscular sense may be excited by the movements of the eye in the attempt to bring one part after another to a careful focus upon the retina. A distant moderately rough object appears quite smooth.

Over and above all these, we have the previously mentioned association of ideas derived as the result of experience from the other senses and particularly that of touch to assist us.

The sensations derived from handling and moving the object and by appreciating its weight, are all stored in the mind, so that whenever we look at the object or another of the same shape, the mind calls up the old picture and judges of it as solid. Again, if we strike a hollow ball, a sound is produced which our sense of hearing tells us could only be produced by a hollow substance. We cannot say by the eye alone, when we look at a round object whether it is hollow or not, but the imagination conjures up the previous sensations derived from the muscular sense and senses of sight, hearing, touch, of objects alike in appearance enabling us as a rule to form a fairly correct estimate.

With one eye alone, we can estimate the solidity of an object accurately enough, but we are merely bringing the sensations derived from the use of two eyes into the presentation. It is to binocular vision that we are mainly indebted for our correct appreciation of solidity.

The evidences of solidity acquired by binocular vision are sometimes resisted by our previous experience. In the pseudoscope the picture of the outside of a mask ought to be recognised as a hollow mask. But the mind refuses to entertain the idea of a human face being hollow; its experience never having known such a thing. It is very conservative about admitting anything new, it clings to the old impressions which are already well fixed, and it is only if what is seen fits well into its previous judgments that it will accept it.

The idea of solidity may be derived from a flat picture, as well as from the combination of two dissimilar perspectives. If the perspective projection of the picture and the surrounding details, accurately represent the object photographed, it may be seen with one eye as solid. The mind is free to put any interpretation upon it which the previous experience of the perspective calls up. We can produce this better by looking through a tube so as to limit the size of the field of vision. With both eyes we of course recognise the picture as flat. Still water in a picture looked at with both eyes appears opaque, but when looked at with one eye, and especially if looked at through a tube, it appears transparent and acquires an appearance of depth.

Again a solid object may be seen in relief with one eye as the very opposite from what it really is e.g. a seal under the microscope may appear to the eye either as a cameo or as an intaglio according to which idea the mind takes of it. In a binocular microscope the seal is seen as it really is. Again if the hollow interior of a mask be painted like the ordinary outer surface, it will appear to one eye as really being the image of a human face. The mask must be held at arm's length and no shadows must fall anywhere upon it or the perspective will be altered. These results are produced according to our previous experience. If we are more acquainted with a cameo than an intaglio, we will see a cameo in the case of the seal under the microscope: in the case of the mask, as the mind is constantly observing faces it prefers this to a hollow mask which does not recal anything which is met with in nature.

Wheatstone showed that a skeleton cube made of wire may appear in monocular vision either as a cube or something else, according as the perspective projections showed a cube or some other form with which the mind was acquainted.

In binocular vision in these experiments the objects are seen as they really are. Even with both eyes, however, at a distance we are liable to judge solidity wrongly, as the mind then lacks the sensations derived through the muscular sense in the act of convergence. Paintings at a distance may appear as solid, or at any rate as if painted on a different plane. An example of this is seen in some of the paintings in the Louvre where the cornices have all the appearance of being solid.

In both monocular and binocular vision, the optical arrangements of an object or series of objects play only a very small share in telling us what things really are. They merely suggest to the mind a conception, and even the adoption of this conception depends to a great extent upon the antecedent condition of the mind, upon the experience in fact which it has derived from the observation of similar objects.

A RETROSPECTION.

At first, the child is merely conscious of the subjective state,- the mind has no consciousness of the objective condition of anything. The sight of anything novel merely produces an involuntary start. This is the stage of sensation without perception. By and bye however the mind gradually "struggles out" of itself. The child becomes conscious of objects in the external world. The sight of a new play-thing may be pleasant or the reverse, but the child shows its consciousness by a smile or a cry. It has now reached the stage of perception. The further association of ideas from the other senses enables it to judge of the distance size, direction, form &c of external objects. When a group of sensations is once interpreted, the same group of sensations again renewed, is recalled as plainly as in the original perception so that it is difficult in later life, to say what is made out at the time and what has been acquired in earlier life.

That there is a borderland between sensation and perception may be shown in ourselves during sleep, after suffering pain. We are not conscious of the pain but the sleep is troubled, showing that sensation is still present although the mental activity is so lulled as to be unable to perceive and judge. When we do awaken from sleep the mind has to gather itself up as it were, before we become conscious of our condition with reference to the world around us.

Once it has become attentive we can immediately tell the difference between the inward and the outward world, as we have experience to guide us.

For the production of sensation then, there must be a conscious state of the mind: for perception there must also be attention: for judgment we recall our experience. When the mind is inactive or engrossed by some other subject, the sensation may neither be perceived nor remembered,

notwithstanding that we have evidence derived from the respondent parts of the body that it is felt. Thus in sleep we turn away from a bright light shining on the face, although we can tell nothing of its source, nor even remember it afterwards.

Visual judgment then, is the result of a process of training very gradually acquired. But we find in the case of some of the lower animals that they are capable of judgment immediately after birth. They have some instinctive tendencies, according to the mode of life they are adapted for, or according as nature has made it possible for them to derive their means of nourishment. The young duck immediately takes to the water, swimming about as well as if it had always been accustomed to it, the young fly-catcher after issuing from its shell, can secure its nourishment by capturing insects as well as it can in later life. But Man can raise his acquired judgments to a very much higher level than the lower animals, and, in fact, by attention, in the course of time he can reach a remarkably high standard.

Physiological psychology is as yet in its infancy. Our knowledge seems limited on all sides and many questions which the study of it, even with reference to the eye call up, are as yet wrapt in darkness. Daily strides are however being made, and there seems a reasonable possibility of light being thrown upon many subjects which at present seem unanswerable. The psychological results of sight derived through the physiological effects are only a small part of the Ego. All the states of human consciousness are included in the term "I" and it is only by a study of these that we can become aware how immeasurably higher we are both in development and culture than the lower animals.

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