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Vision and Work.

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[Read before the Society, 13th March, 1907.]

Sight is generally stated to be one of the five senses; the others being hearing, tasting, touching, and smelling, but a moment's reflection suffices to show what is well recognised by all physiologists, that the sense of sight is complex. It is a sense which responds only to very short vibrations in the luminiferous ether, and, if we exclude radio active emanations, such as the Rontgen rays, cannot be excited in any other known way. It conveys to us information as regards first, the form of objects; second, the colour of objects; third, the shade of objects; fourth, the positions which they occupy in space relatively to each other; fifth, it is the factor which helps us to determine the apparent size of objects. The functions which concern us in the present communication are the first, third, and fourth.

The Form Sense is usually and very conveniently measured by test types. The types commonly employed in this country are those which we owe to Professor Snellen, of Utrecht and so long as they are regarded merely as a comparative test, and not as an absolute standard, they serve the purpose admirably.

To the form sense the term Visual Acuteness is commonly and we venture to think, somewhat erroneously applied. This function of vision is strictly limited in extent to that part of the field of vision which is associated with the macula lutea. The truth of this observation is easily proved by looking at an ordinary line of print. If the observer fixes his eye on a word about the centre of a line of printing, he will find, that so long as he fixes his eye on the word selected, he is quite unable to distinguish the words on either side of it. Or again, if the observer looks steadily at one of the lines of Snellen's types, he will observe that so long as he concentrates his fixation on one of the letters, he is quite unable to see the others in the same line. This is specially true for those lines which contain the smallest characters. If one of the two letters which should be seen at 36 metres by a healthy eye is

steadily fixed, most people, although not all, will be able to form some idea of the other one. This they do probably by their light sense and not by their visual acuteness. Visual acuteness, properly so called, occupies a space in the field of vision represented approximately by a cone, the apex of which is at the first nodal point, and which has an angle of about forty minutes.

The whole field of vision for each individual eye in health extends in the horizontal direction to about 160 degrees, and in the vertical direction to about 140; from which it is obvious, that the form sense, if taken as synonymous with the visual acuteness, concerns an extremely small portion of the field of vision. This limitation of the visual acuteness, as is well known, corresponds with an anatomical peculiarity in the eye. It depends upon the fact that that portion of the retina, which is known as the macula, has special end organs which, no doubt, are associated with a person's power of reading or writing. A very short way from the macula the retina possesses no visual acuteness at all in the proper sense of the term, although here it posseses the power of distinguishing colours, of differentiating gradations of shade, and of perceiving movement. Thus, if I look at a point on a wall a considerable number of feet below a picture frame, I can tell quite well that the picture frame is round, oval, oblong, or square as the case may be. I have a perfect idea of its form, and even of its size, although I am quite unable to see any of the details of the picture. Such perceptions of form are probably a function of the light sense or of the power of distinguishing shades, but they suffice to show that the usually accepted view that the form sense and visual acuteness are synonymous requires to be modified.

The question naturally arises, what functions of vision are necessary to enable a man to work? The answer to that is: it depends entirely upon the nature of the work. A man would require good visual acuteness to be a clerk, or a watchmaker, or a typewriter. There are many occupations where visual acuteness, in this restricted sense, is necessary; but, on the other hand, there are many forms of occupation, especially labouring, which seem to require almost no visual acuteness, but demand three things: first, the light or shade sense; second, the rough ideas of the form sense obtained from the light sense; and third, the sense of alignment. Given these, a man can do almost any kind of labouring work, and hence, we regard it entirely as a mistake to

attempt to express a man's earning capacity in terms of his visual acuteness. It appears to us to be an erroneous method of estimation.

A simple experiment will serve to illustrate the truth of the views here enunciated. Let a small coin be placed on the table to either side of the observer at such a distance to his side that the image of the coin is not formed on that part of the retina with which the person reads, but on a part more towards the periphery. Two things are found to be true. In the first place, the person who is making the experiment is aware of the form of the object; he sees that it is round. In the second place, he will experience no difficulty whatever in raising his fist and striking the object every time he makes the attempt. To take a concrete example, I put a small piece of paper on the table in front of me, and I look steadily at it with my right eye while I close my left. I then take a coin and put it to the right hand side of the fixation object, and I approximately make the distance of the coin from the fixation object the same as that between my eye and the paper; so that the angle between the axis of vision and the line joining the first nodal point of my eye with the coin will be approximately 45 degrees.

Yet, I am conscious of the round form of the object which lies away to the side of the fixation point and, although I keep steadily looking at that fixation point, I have no difficulty whatever in raising my fist and coming down on the top of the coin.

Indeed, if I desire, I can strike it every time with the point of any one of my fingers. The striking of an object then, even lying to the side in the manner that this coin has done, depends not in the least on binocular vision nor on visual acuteness, but on what here may well be called, for the sake of convenience, the sense of alignment. Further, it is to be observed that for this sense of alignment visual acuteness, in the restricted sense of the term, is not required. It would be quite impossible for me to read any characters with that part of the retina on which the image of the coin is made. All that is required is that the light sense is sufficient. We thus come to an important conclusion, namely, that most forms of work can be done with one eye. Nature has endowed us with two eyes so as to give us the intuitive sense of the third dimension, but two eyes are not required, at any rate, for most forms of work.

The periphery of the retina is especially adapted for the per-

ception of movement. Thus, if a person with a healthy eye look straight in front of him, and hold up his right hand so that the angle between the line of vision and the line joining the fingers of the hand with the eye is approximately 90°, and if the fingers of the hand be made to move, the person is at once conscious of the slightest movement; not only so, but by his light sense and by his power of distinguishing movement, he is able to locate the object perfectly well in space, at any rate so far as its alignment is concerned. Thus, we see that for the work of a labourer visual acuteness is not required, but only this sense of alignment which depends upon those stimulations of the retina which are more particularly associated with the light sense.

One other observation falls to be made. The sense of alignment is all that is required for the employment of the larger tools. Again and again I have found persons who are possessed of only one eye quite able to use a hammer, or to wheel a barrow, or to handle a spade, or pick, or shovel, and any one who tries it will find that he experiences no difficulty whatever in performing any of these manipulations with one eye shut. The reason of this is perfectly obvious; in all these forms of labouring the important matter is not the relative distances of various objects to each other, but it is the alignment, and the absolute distance of the object from the person who is engaged in the work.

One other remark may be made in conclusion. In an earlier part of this communication it was stated that the visual acuteness is a function of that part of the retina which is known as the macula lutea. There are good grounds for believing that it is also a function of certain definite centres in the cerebral cortex. If a young child, say between the ages of 1 and 3, begins to squint with one eye, then if that squint is allowed to remain for any length of time, the visual acuteness undergoes serious and permanent deterioration; probably it does so within a period of two months from the onset of the squint. Now, if later in life the eye becomes straight it is found that good visual acuteness, as tested by Snellen's scale, is not regained, the visual acuteness may improve a little, but only very slightly, although the patient will have that perception of form which depends upon the light sense. The explanation of this circumstance, which seems most probably true, is, that in the early years of life the cerebral cortex becomes differentiated according to the function which it is afterwards to subserve. From the squinting eye no stimuli suitable

for the development of the visual acuteness are received, and consequently the cortical centres connected with that eye never have proper visual acuteness. On the other hand, if the squint takes place subsequently to the development of the cortical centres, say, after the child is six years of age, then it is generally found that the squinting eye, as well as the other one, has good visual acuteness.

If a patient who has this amblyopia or defective visual acuteness from squint loses by accident his good eye, it is generally found that although the visual acuteness in his remaining one does not materially improve, yet he has, as a rule, no difficulty in performing any kind of labour. The speculations which such observations awaken are of great interest. It would almost seem that during the first years of life, it is the mind that arranges the brain and not the brain the mind. They also throw considerable doubt on the theory that the macular area of each eye is represented on each side of the cortex.