	Perfect cure.	Cosmetic cure.	Still diverging.	Converging.
Average age of treatment ...	24 years.	11 years.	17 years.	
Percentage of results ...	36 per cent.	30 per cent.	17 per cent.	17 per cent.
Binocular vision [*] present, in cases where looked for, after treatment ...	100 per cent.	—	100 per cent.	50 per cent.
Diplopia as pre-operative symptom ...	68 per cent.	0 per cent.	32 per cent.	25 per cent.
Diplopia as post-operative symptom ...	40 per cent.	60 per cent.	—	100 per cent.
Faulty fixation before treatment ...	0 per cent.	25 per cent.	35 per cent.	25 per cent.
Squint amblyopia ...	25 per cent.	25 per cent.	75 per cent.	0 per cent.

These figures were taken from cases seen during a period of three years, on an average, after the last operation.

Only 25 per cent. of "perfect cures" needed a second operation. All the cases marked "still diverging" were operated on more than once.

(To be concluded)

THE VISUAL PERCEPTION OF SOLID FORM*

BY

E. M. EATON.

It is almost universally accepted that the binocular element is the essential factor in stereoscopic vision. Several of the attributes of uniocular vision have long been recognized as contributing to the impression of relief, or to the sense of depth, but it is generally considered that the vision obtainable by such means differs in a peculiar essential from that which has the quality described by Sir Charles Wheatstone as stereoscopic. I am convinced that this view is erroneous, and in the following paper I hope to satisfy you that it has no justifiable foundation.

What is the essential quality? It is difficult to obtain agreement on this question, for it concerns a subtlety of personal experience that

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perhaps cannot with fulness be expressed in words. I shall, however, endeavour to answer it in some measure, and shall explain why I think I am justified in saying that the stereoscopic quality is not an exclusive attribute of binocular vision. This will involve a restatement of the principles of binocular fusion on a basis of less intimate organization of the two eyes than that commonly assumed.

As we have to deal with a particular quality of visual feeling, it will be of interest to consider first some of the analogies with the other senses. Every sensation which tells us anything of the outer world, be it a sensation of hearing, of sight, or of any other kind, consists of two parts between which a definite demarcation can be made; there is a physical sense impression with its associated primitive feeling quality, and there is a modification of consciousness which has a reference to the object that gives rise to the sense stimulus. The former is independent of our experience, and is determined by the fixed attributes of our sensory mechanism; thus, heat and cold, high pitched notes and low pitched notes, red light and blue light, all give rise to specific qualities of feeling which are inevitable in character; that is, they are such that we cannot by any process of thought make a choice in the type of feeling which is aroused by them, nor can we even conceive the possibility of our having any such choice. On the other hand, if when we hear a certain sound we immediately become aware of the passing of a railway train, the state of consciousness established is not an inevitable one; if our past experience were different the effect upon the mind would likewise be entirely different. Yet the first, or possibly the only, thing of which we may be conscious is the train in motion, the sound as such may not be consciously noticed.

When a characteristic type of sensory impression is habitually associated with a certain nature of object as origin, then consciousness of that object tends to become an immediate result of such an impression; and, when this condition is reached, the interpretation of the impression becomes an integral part of the sensation; in other words, sensation merges into perception and ultimately the two become undifferentiable. The more accurate and the more capable of conveying unmistakable characteristics a particular sense may be, the more fully will it acquire this secondary character, and as vision is by far the most exact of our senses it has this adjunct most fully developed. Hence it is with strict accuracy that we say we see objects and not the light of objects, unless under conditions of very feeble illumination, or where from any other cause objective interpretation is difficult or impossible. Hearing is much less comprehensively informative, and the perception to which it gives rise is chiefly one of an action, combined, as a rule, with the actual sensation of sound. To some extent, therefore, we are entitled to say we hear a tramway car or an

aeroplane ; but probably the immediate perception in most circumstances is that of some sort of motion, and unless the impression is a very characteristic one, it may be more nearly descriptive to say we hear the sounds themselves, further conception being for the most part due to inference. The distinction concerns the question : What is the state of consciousness aroused directly ? are we aware of an object or of a sense impression which we interpret ?

In the case of vision there is no doubt ; under ordinary conditions we see objectively ; our immediate consciousness is of the object with all its outward properties. Solid objects are no exception. Those attributes of the visual impression which are characteristic of objects of this class produce the visual feeling of the presence of a solid body, the quality of feeling, as I understand it, that constitutes stereoscopic vision.

It is customary to regard the dissimilarity of the fusible images upon the two retinae as a specific property which gives rise to this quality, but on the analogy of other kinds of sensation, any feature of the impression which is habitual, and which is sufficiently characteristic, ought to have the same effect, and I think it undoubtedly has.

Why should the specific function of binocular vision have been generally accepted for such special differentiation ? There are, I believe, several reasons. The first is that it is the element which is most easy to abstract experimentally from our complete vision ; we have only to shut one eye. Consequently we have a ready opportunity of observing that our vision suffers something by its loss, and we are apt to overlook that were we as easily able to abstract, let us say, the shadow effects from our impression, vision again would suffer. The second is, that experiments of the type of Hering's falling beads would seem to suggest that binocular vision is the all-important factor in stereoscopic judgment : this, however, is an entirely illogical deduction to make from them. They do not compare binocular vision with other distance guides, but with a state of almost complete absence of all guides. Another reason is, that one of the weaknesses of the function of binocular vision—its elasticity—allows it to act in the viewing of stereoscopic photographs through instruments which, being incorrectly constructed, place the other and more stable factors in stereoscopic vision into circumstances which do not appeal to them as habitual, and they consequently cease to contribute to it ; in fact, to some extent, they oppose it. Our very elastic binocular vision is the only one of our major stereoscopic factors which is acting with full effectiveness in the stereoscopes we commonly use, and therefore its introduction or exclusion is, in these circumstances, the cardinal factor, but the circumstances are not normal. Finally, there is the influence of

stereoscopic lustre, the consideration of which I must postpone to a later stage.

I shall speak of only two of the many factors in stereoscopic vision; first, binocular vision, because of the peculiar importance which is customarily attributed to it; and, second, the sense of perspective, because I regard it as the greatest of all the factors, and because it will serve well for purposes of comparison. It is necessary, however, to consider, first, certain points regarding the sense of form, and the power of selective suppression of retinal images.

The sense of form is often spoken of as synonymous with, or at any rate as being measurable by, the acuteness of vision. Some observers maintain, however, that the sense of form is wholly distinct from the acuteness of vision, and that the recognition of the shapes of objects is a specific sense function. This is an important distinction, although it would seem doubtful if what we ordinarily estimate is not the same sense as applied to minimal sizes. The term "form sense" is, in any case, a somewhat arbitrary one, as this function is not of an elementary nature; as well as psychological factors, it involves several sense factors which may be grouped under the term, sense of relative direction, or, relative directional projection.

The acuteness of vision is concerned with the minimal appreciable separation of image points, but it is obvious that there is another factor which takes account of the degree of this separation. They are without doubt functions of the same sense. The relationship of the two functions might be compared to that between the light minimum and the light difference, although the analogy is an imperfect one. As in the case of the light sense, the increment necessary to make an appreciable "difference" is greater than the interval between zero and the "minimum." The differential factor is less exact in another respect; it is subject to modification owing to suggestion, as is exemplified in many familiar illusions: it is also subject to variation of psychical interpretation on definite geometrical principles quite apart from illusion.

This sense tells us the size and plane of the angle which the line of vision associated with any particular position on the retina makes with the line of central vision, and also the angular relationship of any two or more of such eccentric lines of vision. I use the term "relative" directional projection as distinguished from "absolute" directional projection, which is a much less accurate function involving other factors which in effect take account of the position of the eyes. The chief of these is the relationship of the foreshortening of retinal images to our conception of the form of the objects that give rise to them; during alteration of fixation the muscle sense has an importance also, but as a static factor it appears to have little value.

A definite explanation is available for the development of this function as a sense integer through experience, from the more primitive power of discriminating the values of the separation of stimulated retinal points. In uniocular vision an object whose image falls at any particular point on the retina will always be found in the same direction relatively to the eye, irrespective of distance. It is true that uniocular vision is not our customary vision, but in the matter of relative directional projection it does not differ from binocular vision. I shall refer to this subject later.

The power of suppressing the image of one retina is familiar, but we can under the influence of sufficiently compelling circumstances, and to some extent at will, suppress parts of the image of each retina, so that our conscious impression is of a composite view made up in part of the image of one eye, and in part of that of the other. Thus, if our two retinal images do not fit each other satisfactorily it is possible to cut off the bits that project or overlap. Only in comparatively few circumstances do we utilize the whole of both retinal images. For the moment I shall speak only of the possibility of this suppression, and later shall refer to its frequent occurrence.

FIG. 1.

On the original card the columns were set with the 6.5 cm. distance between centres. The figure as reproduced should be viewed at the reading distance with a pair of ordinary + 3.5 D. sph. lenses. Some mixing of figures may be seen, but with concentration it is possible to exclude any figure except the 4 and the 7.

I have marked a series of figures in two vertical rows on the card shown. They are arranged in such a manner that the rows will be superposed when seen through the stereoscope. Certain of the figures will be suppressed, and we shall see only one row composed partly of those on the right, and partly of those on the left. To some extent this may be due to false relative projection, that is to illusion of form, but a detailed study of the figures will show that this is not the whole explanation. From the two groups I see most readily the numbers 3, 4, 6, 7 and 8, but can choose either figure at any level. The 5 and 6 are so shaped that the complete ring of the 6 will fall on the open ring of the 5. If our eyes are fairly well matched we shall be able to see either the 5 or 6,

and after some study of the 5 it is possible to see it with either an open or a closed ring at will. When the ring opens it does not do so by bending away of the line which closes it, but by fading. We can actually observe the suppression occurring. Meanwhile the 4 and the 7 as well as one figure at each other level are fully visible, showing that parts of both retinae are in use.

Fig. 2.

Fig. 3.

Another way of illustrating selective suppression is by means of colours, and that peculiar fluctuation of visual attention known as retinal rivalry. On a card I have drawn two rectangular figures each coloured one half red and one half blue, and have arranged them so that in the stereoscope the right red will be superposed on the left blue and vice versa. Each space may be filled in with red, blue, or transitorily by some people with purple. By an effort of attention we may be able to choose which colour will be seen in either space. If we see two blues or two reds it is obvious that as regards one colour we suppress an area from each retinal image.

A second card is similar except that the name of the colour is written in black letters across each red square. It is now much more difficult to see the blue squares. The sharp contrast of the black letters on the bright red ground fixes the attention, and the images with lesser contrast are not readily seen. This shows how easily the more prominent of two incongruous images may exclude its rival.

I shall point out later that owing to one or other image being favoured by the incident of the relationships of contour, such suppressions are constantly occurring in our binocular view of miscellaneous objects.

In light of these observations I think we can understand more fully the phenomena of stereoscopic vision.

There are two chief theories of binocular vision representing entirely different principles: the theory of corresponding points and

that of projection. Both are defective, for both involve serious inconsistencies. The former has obtained more ready acceptance than the latter, probably because it comes nearer to giving an explanation on purely physiological grounds. The theory of projection on the other hand has not been sufficiently developed, and it has in recent times fallen very greatly out of consideration, presumably on account of its seeming incompatibility with a median centre of perception. With appropriate expansion, however, it can be so formulated as to be entirely consistent with the facts, and to afford a complete explanation of them.

The classical theory of stereoscopic vision is elaborate and beset with difficulties. When we bring it to bear on the relationships of objects other than distant ones, it becomes necessary to assume that comparisons are made in reference to cylindrical or toric surfaces erected in front of us; surfaces of which nothing in our experience would ever lead us to become aware. This involves the further assumption that in the ordinary use of the eyes we can estimate relative values of retinal disparation, that is in terms of their effect, without being able to appreciate when zero is reached. Such a combination is hardly credible.

It is of course obvious that there are corresponding points, and that there are horopters geometrically, in fact they can be discovered by careful physiological experiment; but it does not follow that they have a physiological significance. It has been suggested that each pair of corresponding points is linked up to the same nerve cell, but this view has been shown by McDougall* to be untenable. Hering went so far as to postulate that definite amounts of disparation of stimulus have fixed depth values.

If such a correspondence and fixed signification were native characters of our visuo-psyche mechanism, it would be contrary to the analogy of all other sense interpretations: but apart from that it can readily be shown that such a view does not help us. During the course of growth in childhood, the displacement ratios would be deranged as the interocular distance gradually increased. The growth of the eyeballs is not a compensatory factor geometrically, and in any case it is approximately completed much earlier than the growth in breadth of the face. A re-adjustment of the meanings of given amounts of disparation would be necessary, thus throwing us back again on the criterion of experience.

If retinal points are not associated congenitally there would appear to be no means of their becoming so in a direct sense by acquirement, for images of individual points fall on corresponding positions only in distant vision, or if the source should chance to lie on the horopter. We much more often use the eyes for

* W. McDougall, "On the Relations between Corresponding Points of the two Retinae," *Brain*, Vol. XXXIII, 1911.

comparatively near objects than for distant ones, however, and associated image points, therefore, commonly fall at positions that do not correspond; positions that are continually varying with our changing fixation. The two points of central vision are the only points which by experience have a direct means of becoming associated. It follows that other points will have an indirect correspondence when their lines of vision bear to their respective lines of central vision a relationship indicating similar projection. This I believe to be the limit of the association of so-called corresponding points; it explains the possibility of discovering them by experiment, and it further explains the great difficulty that is found in doing so. No other view so fully accounts for the fact that many squinting eyes develop a new system of corresponding points, a condition which, if this view is right, is but a geometrical concomitant of the acquirement of a new centre of fixation.

Not only does the direct physiological association of corresponding retinal points appear to be improbable, but its assumption is unnecessary.

We have a sense of directional projection both relative and absolute developed in connection with each eye, and the point of crossing of the two lines of vision associated with any point in space will fix its position in three dimensions, the intersection being the only point common to both axes. The fixation of vision on any particular point by correlating the absolute projection as determinable from each eye, will permit of a very accurate estimation of the relative position of any two points, for this can then be determined in a similar manner by the much more exact sense of relative projection alone.

As the directional projection of an image is an act of the projection sense of the eyes individually, so the distance projection is an act of the same sense of the two eyes together.

That is one aspect of the binocular factor, and it explains the very accurate relative location of individual points without the pre-supposition of any hypotheses except one, namely, that the function of directional projection continues to be exercised in binocular vision through each eye individually, unaltered in a physiological sense. Of this I shall speak later.

When instead of a point an object with magnitude and form is considered, there arises in addition the question of the signification of dissimilar form by the images on the two retinæ. Were we to fuse such images in the sense of superposing them, it would be necessary to establish a condition of error of relative projection in one or both eyes, but if we fit one image into the other, not on to it, they are a perfect fit, without modification. If we look at a sphere with one eye and imagine a line drawn around it at the visible periphery as seen from that position, and if then we look

with the other eye and mark the periphery from the second position, we have the potential silhouettes of our binocular image. As our consciousness is of a solid body those silhouettes will fit on to our conscious image without modification of form. The whole surface seen will include the large area common to both eyes, and the strip particular to each.* The same principle is applicable to all solid forms. The effect of this binocular view is to give us a certain amount of additional evidence in the construction of our solid image, but not to make the visual mechanism react in a modified manner in regard to each retinal image. This extra evidence is not on the peripheries only, we get two complete perspectives, each perfectly fitting the other. These perspectives differ considerably in the nearer parts, but gradually merge into equality as distance increases. If we look at a stereoscopic pair of photographs with straight lines represented running towards us, as for example the tramway lines on a street, it will be seen that the directions on the two pictures are quite different, yet they fit with absolute comfort when seen through the stereoscope: there is no delay, discomfort, or feeling of unrest, such as is experienced where one image interpretation is really accommodated to the other. This latter condition can be observed through the stereoscope on cards with dissimilar figures, where the dissimilarity is not sufficiently great to cause actual suppression of one image; a 1 and a 2 if suitably formed will serve the purpose.

The extreme case of differential images would be represented if we were able to converge each eye 45° and focus accordingly. Then we could look at the front and the side of an object simultaneously, the face and the edge of a coin for example. The mental images would still fit into each other perfectly, but of course they could not be made to coincide with each other. The individuality of each retinal impression exercises an influence on the perception, but there is no intermediate sensation. Ordinarily we are not conscious of retinal images however like or unlike they be. We are conscious of nothing within us, only of an object without.

Our knowledge of retinal images tends to make us exaggerate the importance of a particular sub-station on what is merely a system of communication. The fact that the images are of this shape or that at the place where light radiation transfers the message to nerve conduction, gives no indication, ipso facto, of our ultimate perception, either as to its superficial form or its solidity.

As the perception of form is a function of the sense of relative projection, we have in this fitting of the images another call on the

* Subject theoretically to marginal suppression or transparency; *vide infra* the impossibility of seeing around objects. The effect in the case of a sphere is under ordinary circumstances, however, too slight to be appreciable.

hypothesis with regard to binocular projection of points, that each eye maintains unaltered the influence of its projection sense individually in binocular vision.

Although for descriptive purposes I have treated of the binocular sense in two sections, the separation is artificial. Acting as part of the fitting of one image into the other, we have a correct projection of each image point to its true place on the solid image. Over part of the image, however, the distinction which I have drawn is essential. The part that is not common to the two images can receive no binocular aid in the projection of points. This part is represented by the two crescents on the sides of the sphere, and in the case of rectangular convergence there might be no common image points except along one line, according to the shape of the object.

If the various points on the surface of a solid body were projected in accordance with a principle which demanded as a price for the projection in depth a compromise of the interpretation of the retinal images individually, then we should of necessity get distortion.

That part of the object seen through both eyes would have a perspective truthful for a median position of observation: the parts seen through each eye individually would have a perspective truthful for a lateral position of observation. There would be parts of two different perspectives received through each retina. Those parts of the retinal images common to both would be given a modified interpretation, and the remainder would be interpreted as in unocular vision. The sense of relative direction would thus be falsified. It may be said that no such distortion is necessary, for we can, and commonly do, see from a median position even with one eye. I shall show, however, that when we do this we get false projection.

This involves a consideration of the axis of vision, a subject regarding which there is a great deal of confusion of ideas.

It is unquestionable that customarily we see from the middle of the inter-ocular space, but this does not require any physiological modification of the effect of the retinal images. We see from one centre which we may place where we please; it is merely the point where we conceive ourselves to be for the purpose of establishing our relationship to the objects seen. Consistency with the distribution and extent of the surface areas of each object available to vision, determines that unless by conscious effort to do otherwise we shall ordinarily place our point of view or centre of visual consciousness midway between the eyes in binocular vision. The line joining the line of fixation to the middle of the inter-ocular space may therefore be described as the axis of perceptive vision. The effect of the eccentric position of the eyes upon the shape of

the retinal images is psychically self-compensatory. If I look at the doorway in the wall on my left my retinal images are far from rectangular, yet without any mental analysis or reconstruction my perception is of a rectangular doorway. The only respects in which the view differs from one seen from directly opposite is in its direction in relation to myself and in the hiding of some of the depressed surfaces. There is no difficulty, in conception at least, in projecting my point of view to a position opposite the doorway and thus seeing from in front. That gives a conceptual axis of vision, an axis of which by mental effort we can definitely make use, but which has no practical importance except for descriptive purposes. If I had another eye at an equal distance beyond the door, the deficiencies of the hidden parts would be filled in; the placing of the point of view at the mid position would be habitual, and thus that position would be through custom the centre of perceptive consciousness, and the axis of conceptual vision would now be the axis of perceptive vision.

We have an optical or physiological axis of vision for each eye, the line of vision with which we are familiar. There is no optical axis of binocular vision.

The theory of a Cyclopean eye, based on that of corresponding points, provided a symbolic central optical axis; but it is strictly applicable only to duplicated images; the angles which the lines of true projection make with it do not bear a constant relationship to the mean of the angles formed with the two optic axes.

In uniocular vision the perceptive axis is variable; in very deliberate uniocular vision, as in shooting, this axis coincides with the optical axis; but when the use of one eye is more casual the perceptive axis is usually in the same line as that of binocular vision, yet there is a great difference in the means by which this is brought about in the two cases. In this median type of uniocular vision the optical axis is merely swung round, in other words, the psychic interpretation of the grouping of angular relationships to the axis remains true to the optical conditions, but as the position of the axis is wrongly interpreted the psychic projection is false. When as in shooting, however, the perceptive and optical axes coincide, the whole system of psychic projection is truthful.

The two conditions are shown in the accompanying figure. If CA is the optical axis and FA the perceptive axis, that is if we falsely believe CA to be in the position of FA, as we do in casual uniocular vision, then the fixation point A will be correctly projected, but the point B will be projected to G: the relationship will be correct but the whole view will have been rotated around the point A.

If on the other hand C is felt to be the point of observation, then CA is the perceptive axis, and both A and B will be correctly

projected. It is possible now to make FA a conceptual axis, and to think of B as lying between A and an imagined point of view at F: this is the part played by each eye in normal binocular vision. The coincident conceptual axes of the two systems of uniocular vision, that is right and left, become the common perceptive axis of binocular vision. In binocular vision with duplicated images the interpretation is made as in the median type of uniocular vision, with projection of the point B to G by the right eye, and to a corresponding point on the right of FA by the left eye.

FIG. 4.

Alterations in the adoption of the various visual axes necessarily have an important bearing on disturbances of orientation in cerebral lesions.

In normal binocular vision the correlation of the two eyes, that is of the two paths of visual information, is made in relationship to the one invariably corresponding line of each, the lines of foveal vision, the optical or physiological visual axes; and for each eye the system of relative directional projection remains intact; that is, although the median line becomes the perceptive axis, the positions of the physiological axes are not misinterpreted. We can observe this in the use of a stereoscope which has no dividing screen between the two eyes: three images may be seen, the middle one being binocular, while the lateral uniocular images bear the same relationship to it that they do consecutively if first one eye and then the other be used separately. It will be pointed out later that although the correlation of the two eyes has reference to the foveal visual lines, it is not necessarily achieved by means of them.

Bilateral vision without physiological fusion and yet with perceptive singleness may be compared to the perceptions arising from the stereognostic senses concerned in the handling of a solid body. If a book is grasped between the two hands we become aware of certain facts regarding the book, its contour, its surface finishing, its unity. The information is gathered from the sides, but the object is perceived to be in front of us. In addition to the perception of the object we also become aware of the more primitive subjective sense feelings, that is of the ordinary sensations considered physiologically. These are referable to the two hands and arms individually; they are essentially and obviously duplicate.

Attention to these sensations would cause duplication of our perception of the object were it not that we have a distinct knowledge from which side each sensation comes, and are thus enabled to correlate them and perceive one book. In the case of the eyes, however, we are unable consciously to distinguish on which retina an image falls, although this differentiation, achieved unconsciously, has an essential influence in binocular vision. I shall show that we may explain on the ground of these relationships to consciousness the fact that under certain conditions we get duplication of visual images.

This phenomenon of double images is very important. It gives another evidence of the maintaining of the correct projection relatively to each eye separately during binocular vision, the assumption of which I have said was necessary to the projection theory. It is also a critical question in relation to the consistency of either theory.

Under what conditions do we see double images? If we fixate a point and any other object comes into close proximity to one of the lines of vision, either between us and the fixation point, or beyond the latter, then one of two things will happen: either we may get duplication or we may receive the impression through one eye only and suppress the other image. We cannot obtain fusion, that is unification without suppression, if one image occupies the fovea and the other is not central; nor can we make images that lie heteronomously off the fovea fuse over it. If a minute ink spot on a piece of paper be observed binocularly, and if a fine needle point be made to approach the lines of vision in a plane about a quarter of an inch from the paper, and in a direction transverse to the interocular line, the foregoing facts can be observed. Sometimes fusion of the two images of the needle point may appear to have been achieved, but closure of one eye will reveal from the parallax displacement that what has happened is the suppression of one image.

In looking immediately past the vertical margin of any object on to a more distant background, provided the latter bears sufficiently distinctive markings to enable us to observe how much of it we do

see, it will always be found that one image of the margin is suppressed and that the amount of background seen binocularly is the same as that visible to the more favourably situated eye. If this eye be now closed the suppressed image becomes available, and the nearer object appears to spring across towards the side of the closed eye. In such circumstances the total of facts available to vision is not consistent with a single point of observation. Given the requisite conditions these phenomena are independent of attention, that is they remain unaltered down to the lowest degrees of attention compatible with perception of the objects concerned.

Under conditions of attention, which of course is a relative term, fusion is not obtainable in the vicinity of the macula or in the position occupied by the images of objects lying between the lines of vision. For a variable distance beyond the macula, a distance which may be much increased by augmented concentration, it is also unobtainable. Another effect of specific effort is that we may be able to retain both images where otherwise one would dominate to the complete exclusion of the other.

Now, according to the theory of corresponding retinal points, all images of objects ought to be seen double if their disparation exceeds certain very narrow limits of fusion. In ordinary circumstances we see no duplicated images, however, and throughout most of the binocular field our perception does not suffer from the parallax displacement which unification by suppression of one image from a pair of duplicates always entails.

In support of the theory of corresponding retinal points it is said that the images are double, but that they are not seen to be so unless specifically attended to. The alternative, and I think the true explanation, is that they are not double until the act of attention makes them so. It is plain that we are quite capable of appreciating duplication in the periphery of the field without special attention, for if we produce even a small amount of diplopia with prisms duplication is widespread.

According to the theory of projection, single binocular vision is normal, and duplication under conditions of attention, whether this be due to prominence of an object in the central field or to voluntary effort, is readily explicable as follows: In order to adapt the laterally placed physiological visual axes to perceptive vision in the middle line, a psychical adjustment of the interpretation of the visual angles is necessary. Under normal conditions of a purely objective perception this is easily accomplished, just as it is easy, in fact almost unavoidable apart from special training, to perceive the rectangular form of a doorway that is not directly opposite the observer. When, however, the macular area is encroached on, or when concentration of attention is exercised, a relatively greater part is played by the element of pure sensation, in the same

manner as attention makes us more definitely aware of the subjective part of the sensation in the handling of a book or other object. This reaches a degree such that the sensational angular relationships to the optical axes, that is the physiological visual angles, become accepted as the basis of perception. But as the axis of perceptive vision is in the line joining the middle of the interocular space to the fixation point, these angles are interpreted in relation to this line. Double images are therefore seen in directions making with the middle line angles equal to those which the optical lines of vision of the object and of the fixation point make with each other (cf. Fig. 3). The distance of these falsely projected images is optically indeterminate, and psychically variable. Pre-conception and the relationship to other objects seen singly tend to place them at the distance of the object they represent; while, in

FIG. 5.

so far as they can be dissociated from these factors, the act of attention tends to carry them towards the plane of fixation. It may be asked, why do we never see in duplicate on corresponding points? If such points have no physiological significance, why should they be an exception? The reason is that from the accident of their geometrical position the double images which they would produce happen to be projected along the same line.

If E and F (Fig. 5) are corresponding points, images of the point B on the horopter, then the angle AKB will equal the angle ALB; that angle is the amount to which KB and LB lie to the left of KA and LA respectively; therefore both images will fall to the left of GA to the extent of that angle, that is they will both fall along the line GB.

(To be concluded.)