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PERIMETRY

The Methods, Means, and Manner of Determining the Size
of a Field or Scotoma*

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A PATIENT'S visual acuity is a measure of the functional activity of his macula. The function of the rest of the retina is determined by means of perimetry.

Perimetry consists in the accurate determination of the limits of the areas of the retina that are functioning normally, partially, or not at all. It is purely a subjective test and the success or failure that attends it depends largely on the patient's intelligence and goodwill.

Accuracy is essential. A few minutes therefore should be spent in explaining to the patient exactly what is required of him. This may advantageously be followed by plotting out his blind spot. He will thus begin to understand the nature of the test and to appreciate that even though a thing is in front of him, he cannot necessarily see it. At the same time he will learn to observe the appearance and disappearance of the object.

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*This paper was written before the meeting of the Oxford Ophthalmological Congress, so that it is in no sense an answer to the communications read at that meeting.—EDITOR.

In order to attain accuracy all apparatus used should be designed to give consistent results.

Methods of Perimetry

Blackboard method.—The earliest method that approached accuracy consisted in seating a patient in front of a blackboard, instructing him to look fixedly at an obvious white mark—the fixation point—and charting out on the blackboard in chalk the areas in which the patient said he could see the object, or those in which he failed to do so. For this purpose, naturally, only one eye was exposed at a time, and the object was mounted on some dull black handle.

This original method had many objections and many modifications have arisen, each attempting to overcome some difficulty.

Objections to the Blackboard Method

(a) *Suggestion.*—The first objection to the blackboard method is that the patient sees the marks on the board and is therefore influenced by suggestion.

No marks, obvious to the patient, should therefore be made. The board may be marked into squares or alternatively into concentric circles with radial lines emanating from the centre.

The position of the point at which the object is lost sight of, or is first seen, is noted in relation to these lines and a similar chart is appropriately marked. In another method the board may be replaced by a black cloth, behind which is placed a piece of paper, and the desired point is marked by pricking the paper through the cloth. Again, black-headed pins, invisible to the patient at the distance at which he is sitting, may be pushed into the cloth, which may conveniently be backed up with thick felt. When the examination is completed, the field or scotomata, so found, may be copied on to an appropriate chart.

(b) *Absence of any form of head rest.*—In the original method there was no head or chin rest. It was impossible, therefore, to keep the eye at a constant distance from the board. If the observations are being made at a distance of one or two metres, a variation of a centimetre or so is of slight importance, but at 33 centimetres, the distance employed in many perimeters, such movement would lead to an error of several degrees.

(c) *Limited scope.*—Further, the board was found inconvenient in that it only enabled one to examine a limited area of the total field of vision.

Theoretically, of course, the eye under examination should be in the centre of a hemisphere and the object should be moved around on its inner surface. But illumination becomes difficult and it is impossible to watch the patient's eye. Förster therefore devised his

arc perimeter. This instrument overcomes both these difficulties, and it is on similar lines that most modern instruments have been made.

The object was still held on some form of unobtrusive handle and a suitable black background was placed behind the arc so that the patient's attention should not be distracted by any bright object, that would have been hidden by the corresponding blackboard.

Further, some surgeons are reported to wear black gloves and even a black coat.

Recording Mechanisms

Next, recording mechanisms began to be added to the arc perimeter so that the recording might be both more rapid and accurate. In order to accomplish this, the object must be propelled along the arc, mechanically or electrically, a marker situated behind the instrument being moved a corresponding and proportional distance; this marker can be made to mark a chart.

The Object

The machine should be so designed that the object alone is moved. It is not infrequently the case that a large object carrier is employed, so designed that any one of several colours may be shown to the patient, and these in several sizes, usually in squares of 1, 2, 5, 10, 15, and 20 mm. edge.

There are several objections to such an arrangement.

In the *first* place the carrier makes a noise, and the patient unconsciously judges its position by the ear rather than the eye.

Secondly, he not infrequently will tell the surgeon that he sees something moving before he can see the object, particularly when the object is small. Unless great care be exercised, erroneous conclusions are liable to be drawn as to the true size of the field.

Thirdly, the carrier is often so made that when it becomes a little worn by use, the disc carrying the colours may revolve while the carrier is travelling round the arc, thus the colour of the object may change without the surgeon being aware of it.

Lastly, the metal plate in which the notches are cut, exposing varying sizes of the object, not infrequently lies a full millimetre in front of the disc carrying the colours. The light is coming from behind the patient, and therefore as the object carrier is moved around the arc away from the centre, the edge of this disc throws a shadow over the object, which increases as the object carrier proceeds from the centre. The result is that, although the object lies well within the field of vision, it may be entirely invisible to the patient.

Therefore different sizes of object of each colour should be employed, and the carrier should be small, and if possible, out of sight.

Mechanical Accuracy

The instrument should be mechanically accurate. There are difficulties in its construction because of the necessity of carrying the power round the curve of the arc. In the past this has been overcome by using gut, string, wire, or chain. They are all almost equally unsatisfactory. They usually work well when they leave the maker's shop, but soon begin to stretch. This results in the recording mechanism being thrown out of adjustment. The instrument should be made with a positive drive through a rackwork and gear wheels, or the like.

Handle.—The handle whereby the mechanism is operated should be of convenient size. It should be worked by movement of the wrist. Some of the more modern machines have a type of capstan wheel. This is too large to grasp in the hand and it is not easy accurately to move it a small amount. Further, the handle should be mounted at some distance from the recording needle to avoid the possibility of the surgeon scratching his hand.

Silence.—As already mentioned, the machine should work silently.

Chin Rest.—Inaccuracy due to improper adjustment

In the McHardy perimeter, and in certain others which were designed before adjustable tables came into vogue, the chin rest is adjusted to the height that is comfortable to the patient. The centre of the cornea may therefore be above or below the centre of the arc. In order to obviate the error that would thus be introduced, the height of the centre of rotation of the arc is adjustable. Two scales are employed, one on the pillar supporting the chin rest and the other on the column of the arc. A special rod is attached to a sliding member around the scale on the chin rest pillar. Its free end is placed opposite the centre of the cornea, and the position of the other end is read on the scale. The column supporting the arc is adjusted until a similar reading is obtained on its scale. This is a very accurate method, but the special rod has to be detached from the machine while a field is being taken out, and not infrequently becomes mislaid or lost. This results in the adjustment of the height becoming a matter of mere guess work. Incorrect adjustment of this nature may lead to an inaccuracy of as much as 10° above and below, although it has very little influence on the size of the lateral fields.

It is preferable therefore to fix the height of the eye relative to the centre of the arc. This is best attained by employing some type of cheek support. The lower edge of the patient's orbit is placed

against this, and the chin rest raised until it just supports the patient's chin. The height of the table, or the perimeter stand, is then adjusted until the patient is comfortable.

Patient's Comfort.—It is essential that the patient be comfortable; if he is not comfortable, he will not be attentive, and if he is not attentive the results obtained will be useless.

Chart

Size of the chart.—In the McHardy, and in a great many other machines, the 180° movement of the object is represented by 100 millimetres on the chart. Priestley Smith, however, uses a chart 90 mm. wide to represent the 180° , that is half a millimetre for each degree. In practice this is found to be amply large.

If a recording perimeter is not being employed it is immaterial what sized piece of paper is used. When copying from a Bjerrum Screen or an Elliot Scotometer, it is possible that greater accuracy is obtained by using a larger scale, for whereas the prick of a needle may be made accurately to half a millimetre or even less, it is not easy to obtain such accuracy with a pencil or even a pen.

Notation of the chart.—The method of axial angular notation varies on different charts. It seems desirable that the notation employed in mathematics should be employed here. The chart represents the patient's field as he sees it, and therefore the notation should be from his point of view. This is possibly a little unfortunate as the axial notation of cylinders in astigmatism is the mathematical one as the surgeon looks at the patient. But as the two are probably never considered in relation to one another, this is unimportant.

Method of attaching chart to perimeter.—In most perimeters, in order to ensure that the chart is placed accurately in the chart-holder, this latter is provided with a central pin projecting about two millimetres above the general surface of the holder. The central point of the chart is impaled upon this pin. This is not too easy to carry out, and the surgeon has been known to prick his finger.

With modern methods of accurate printing, it is quite easy to print the charts so that the central point is an exact distance from the bottom and one edge of the paper. The chart holder has three adjustable stops, two at the bottom and one at one side. The chart is placed with its edges in contact with these stops, and is held in position by a spring. If there is any doubt about the chart being correctly centred, the object is racked out to the extreme periphery, and the arc swung into the horizontal plane. The position of the object is now marked by pressing the chart against the marker. If the chart is correctly placed, the needle prick will be exactly on the horizontal level on the 90° circle.

Once the stops are adjusted, they will not require to be altered until a new batch of charts is employed, and not necessarily even then.

The principal objection to the central pin in the chart holder is that when the object is racked to the centre the marker, if correctly adjusted, strikes the central pin and is bent to one side. Further, the central pin makes it difficult to renew the linoleum, and this gets worn out near the centre and then it is very difficult accurately to mark out a small scotoma near the fixation point.

Stops on Arc Bearing

It is convenient to have some form of mechanism to indicate to the surgeon when the arc is exactly in the vertical and horizontal positions and at every intervening position 15° apart.

Bjerrum Screen.

Some observers prefer that the patient should be at a greater distance from the object than the 33 centimetres of most perimeters. They work at a distance of a half, or one metre, or even two metres. In general, smaller objects are used and no attempt is made to examine any area other than that of the centre of the field.

The best form of screen to employ is one of black cloth or velvet, on which radial and circular lines are worked in black thread. These are invisible to the patient at the distance at which he is sitting. The radial lines are marked at every 30° and the circular ones at every 10° . The diameter of the circular lines has, naturally, to be calculated for the distance at which the chart has to be used, the circles becoming progressively larger in proportion to the tangent scale.

It is convenient to stretch the screen taut over a frame and to use the head of a white-headed pin as the central object on to which the patient is to fix his gaze. The limits of the patient's field of vision, or of any scotoma, or of his blind spot, determined by using a small object on a long black handle, are marked on the screen by putting in small black-headed pins which are invisible to the patient. The areas so found are transcribed on to a conveniently sized chart.

Such methods are only applicable to the central 30° to 40° .

Elliot's Scotometer

This is virtually a Bjerrum's screen mounted on a circular board which can be rotated around its central point. It is designed to be used at one metre. A radial scale is worked in thread on the front and an axial degree scale is marked on the back. It is more rapid in use than a Bjerrum for the following reasons:

When using the Bjerrum screen, the surgeon first has to

determine the position of the scotoma, plotting it out on the screen with pins. He then has to find the numerical value of this position. For it is only by this means that he is enabled accurately to copy it on to a chart.

With an Elliot, on the other hand, this numeration of the position of the scotoma is operated by the machine. It therefore takes less time to use an Elliot than a Bjerrum.

There are no mechanical difficulties in making an Elliot into a self-recording scotometer. It would be necessary to incorporate a suitably shaped cam to counteract the distortion introduced by the surface being flat instead of being part of the wall of a sphere.

Reasons for popularity of Bjerrum and Elliot methods

1.—*Angular speed of object.* When using either of the methods the object is usually moved by the surgeon, unconsciously, at about the same speed as when using a perimeter. As the distance from the patient is much greater, the angular velocity is proportionately less, and the patient therefore has time to make up his mind when he sees and when he loses sight of the object, and to expostulate. When working close to the patient, as with certain instruments, the angular velocity is very much greater, and the image of the object moves so rapidly across the scotomatous area on the retina, that the patient fails to observe many of the slighter changes.

2.—*Size of object.* In order accurately to determine the exact borders of a scotoma only a very small area of the retina should be stimulated at a time, that is, the angle subtended by the object should be very small, one or two minutes of arc.

It is not convenient to work with an object much smaller than a millimetre or a millimetre and a half in diameter. If the angle that is to be subtended is to be small, the object should be viewed from a distance.

Comparison of Perimeter with Screen or Plane Scotometer

The advantages of the screen or the plane scotometer are twofold.

1. They are less complicated.
2. The instruments are much cheaper.

Their disadvantages compared with a perimeter of sound construction are many.

1. There is a tangential distortion of the field which requires to be corrected when it is transcribed on to a chart.
2. There is a relative decrease in the size of the object as it is moved away from centre. This cannot be corrected.
3. The periphery of the field cannot be examined.

4. They are not self-recording, and therefore are slower to use.

5. They are more cumbersome.

6. But the important advantage of the perimeter is that the surgeon can watch the patient the whole time, to see that he is keeping his eye fixed on the central target. When using a screen the surgeon must be watching the screen to see where he is holding the object, and how he is moving it, and he cannot possibly attend to the patient. With an Elliot, he can watch the patient, but the shape of the instrument makes him stand to one side, and he cannot get as good a view as he can when using the perimeter.

The apparent disadvantages of the perimeter are twofold. In the first place since the object must be viewed from a distance of about 33 centimetres very minute objects cannot be employed.

In the second place, the recording mechanism reduces the size of the blind spot and any scotoma to such a degree (about 11 times) that small changes in the size are not easily detected.

Both these difficulties may easily be overcome, thus adding to the perimeter those advantages hitherto only obtainable with a Bjerrum screen.

Minute Objects

In order to obtain a really small cone of light the object should consist of a suitably sized polished sphere of black glass. The observations are carried out in a dark room and a single light is placed immediately over the patient's head. With the object at 33 centimetres, with an ordinary carbon filament ophthalmoscope (Stern's) lamp, and a spherical surface of 3 mm. radius, the cone of reflected light subtends 1 minute of arc. With a suitable resistance in the lamp circuit, various brightnesses of image may be obtained, and by interposing coloured screens, various colour fields may be plotted out.

Large Scale Chart

As plotted out by the recording mechanism of an ordinary perimeter 1 degree of movement of the object is represented by about half a millimetre on the chart. When plotted out in this scale the blind spot is quite small and it might become enlarged by 1 degree or more before the enlargement would be very obvious. If, however, the scale be 8, 10, or 12 times greater, small variations in size immediately become apparent.

In a perimeter with an arc 33 cm. in radius, the object moves 5.8 mm. in passing through 1 degree.

The blind spot plotted out in this scale would be a convenient size.

Special Chart Holder for Large Scale Chart

In order to record the size of the blind spot or a central scotoma in this large scale a special chart holder is employed. It is curved so as to form part of the surface of a sphere of a slightly lesser radius than the radius of the arc. It is some 30 cm. long and 15 cm. broad. The special chart is held on its convex surface. It is attached by a hinge to an arm which fits on to the chin rest pillar. When not in use, it is easily removed. When in use, the chart holder lies just below and in front of the patient's chin. It is so mounted that the hinge allows it to be swung up against the arc, and it is so adjusted that the centre of the chart comes to lie opposite the fixation point.

The object has a small needle mounted on its surface. Thus when the chart is brought up against the surface of the arc, the exact position of the object is recorded.

The chart represents an area some 52 degrees from side to side and some 26 degrees vertically.

By this means the size of the blind spot, or central scotoma may be recorded rapidly and permanently. In conjunction with the minute reflected object mentioned in the last paragraph as accurate results may be obtained with a perimeter as with a Bjerrum screen or an Elliot scotometer.

Taking the Field when the patient has a Central Scotoma

When the patient has a central scotoma, it is obvious that it is impossible for him to fix the central object. He is therefore instructed to place the tip of his index finger on the target and to look in that direction at the tip of his finger. Usually he can do this with comparative accuracy, so that the limits of his scotoma may be determined with precision.

It may happen, however, that he has some sensory disturbance of his upper limbs, when he will not know exactly where his finger is, and this method will be useless.

Under these circumstances, if he has no scotoma in the other eye, he uses it to fix the target. The test object must be hidden from the fixing eye. This may be accomplished by using a tube down which he looks.

Alternatively a green glass through which the white central target may easily be seen is placed in front of the fixing eye. A red object is used to determine the size of the scotoma. The red object cannot be seen by the fixing eye through the green glass; therefore when it is seen it must be the eye with the central scotoma that sees it.

Both these methods presuppose that the patient has no heterophoria. If he has and the extent is known, the target may be suitably displaced to correct for it.

It must be extremely rare to find a patient who has sensory disturbances of both upper limbs, and a central scotoma of one eye, and the other eye unaffected.

Size of Objects

It is usual to define the size of the object employed in taking out a field by mentioning its width in millimetres. In different machines these objects may be at very different distances from the patient. The important point, obviously, is the angle subtended by the margins of the object.

The sizes of the objects supplied with most perimeters are 1 millimetre, 2, 5, 10, and 20 millimetres. These approximate to 4° , 2° , 1° , 20 minutes and 10 minutes of arc, when employed 33 centimetres from the patient's eye. The largest is too small. The smallest is too large.

White Objects.—The largest should be oblong subtending 10° by 5° . It should be mounted so that it moves along the arc with its wider edge towards the centre.

The others should be square, the edge subtending 4° , 2° , 1° , and 0.2° .

Coloured Objects.—It is usual to employ blue and green, as well as red objects, although red are the ones most frequently used. These objects should be square and subtend 4° , 2° , 1° and 0.2° respectively.

Grey Objects.—Occasionally it will be found useful to be able to test a patient with a grey object, particularly if it is known that he suffers from some form of colour blindness.

Illumination

Within wide limits, reduction in illumination will have only slight, if any, influence on the size of the field for white. With colours, however, it is otherwise, relatively slight reduction causing considerable changes in the sizes of the fields. This is particularly so when working with blue and green in artificial light, for when the illumination is reduced by inserting a resistance, the character of the light varies, red rays being predominant.

It is stated that when using a grey object, if the illumination be of suitable strength, fields can be plotted out that correspond accurately to each of the various colour fields. These observers imply that the stimulus of colour is merely a question of intensity. In view of the work that has been done on the variation of colour fields in cerebral tumours and in hysteria, it would appear that, if the facts are as stated, the explanation, at least, is wrong.

Standard of Illumination

No standard of illumination has been agreed upon. But it is obvious that if the results of different workers are to be comparable,

the conditions under which they work should be alike. Daylight varies in colour and intensity from day to day and hour to hour. The standard should be an artificial one and the examination should be carried out in a darkened room. The lights should be diffuse, three lamps may be conveniently used, one on each side of the patient, and one over his head. Stern's carbon filament ophthalmoscopic lamps are quite suitable, but unfortunately their life is only a few hundred hours, and the longer they have been used the less light they give out, and the more red it becomes.

More recently a new type of artificial daylight has been introduced (Sheringham), and it is possible that if it becomes commercially successful, this lamp might be adopted as a standard if its intensity can be suitably controlled.

Size of the Field

As already mentioned, unless the eye be properly placed opposite the centre of the arc, the field may be made to appear to be contracted above or below, as the case may be. Quite apart from this, when the nasal field is being plotted out, unless the head be turned a little to that side, the nose may cause an apparent contraction of this field.

If a chart be examined it will be observed that the normal field is nearly circular, with the blind spot as the centre, with the exception of the area cut off by the eyebrow. Often in patients with prominent eyes, if the head be tilted backwards, and the surgeon raises the upper lid and eyebrow with his finger and thumb, the upper field may be considerably increased in size, so that the field may almost become circular.

Difference in size of Field for seeing and Field for losing Object

When taking out a field with a 1° object, particularly when there is some obvious contraction, two quite distinct margins may be plotted out.

1. The field as determined by the points at which the patient sees the object when it is being moved from the blind area to the seeing one, i.e., towards the fixation point.

2. The field as determined by the points at which the object is lost sight of when moved into the blind area, i.e., outwards.

The second of these fields is invariably found to be larger than the first. This is denied by certain workers.

Similarly when working out the limits of a central scotoma, the scotoma as determined by moving the object inwards will be found smaller than when working outwards.

With a 1° object and dull illumination there may be as much as 10° difference in the size of these fields. But with an increase in

the size of the object or of its illumination, they more closely approach one another in size.

(This is a psychological phenomenon and is not peculiar to perimetry. If a watch be brought up gradually to the ear till heard, and then withdrawn until no longer heard, it will be found that the second position will be considerably farther from the ear than the first).

It is usual to accept the field where the object is seen as the true field.

Variations in Colour or Intensity of Object

The patient may remark that the object appears to change colour, or pass into a fog as it is moved around the arc. If he does so, the size of the object should be reduced, and, if necessary, the colour changed. In this way a scotoma will quite probably be discovered that otherwise might have passed unnoticed.

Movement of the Object

The speed of movement of the object has considerable influence on the size of the results obtained when examining a field or scotoma.

Under certain conditions of the cortex cerebri, retina, or the intervening tracts, the sensitiveness of the retina to light may be so reduced that it is inappreciative of the light coming from even a large white object if that object be stationary, and is only stimulated by the change from dark to light and vice versa.

When taking out a field, therefore, great care should be taken that the object be moved sufficiently slowly. In such a case, the field taken out with a 10° object may be nearly full. When a 4° object is used a much smaller one will be found, and the field taken out with a 1° object may be quite contracted.

But if the 4° object, or even possibly the 1° object be moved about fairly rapidly in the area that was blind to the slowly moving 4° object, the patient may see it. In the same way the retina blind even to a 10° object may be stimulated by moving that object about rapidly.

No standard of speed has been determined or agreed upon, for the moving of the object, but if scientific accuracy is aimed at it is obvious from the above facts that some speed limit should be observed.

Again, when determining the size of a scotoma, the speed of the object should be quite slow. The object is small, and therefore the stimulation slight, and the patient must be given time to appreciate its presence. If it be moved rapidly, the patient will inevitably fail to observe slight changes in intensity or colour and inaccurate results will be obtained.

Tests to be applied

1. The maximum field as ascertained by using a 10° white object. If the field be found to be contracted when moving slowly, the object is moved backwards and forwards as described above to see if the "field for a moving 10° object" is larger.
2. Field for 1° white object or other sizes.
3. Field for colours.

If these coloured objects subtend 10° or more and are well illuminated, the field obtained with them is nearly, if not quite, as large as that obtained with a 10° white. If, however, they are as small as 1° the fields are markedly smaller. Blue is the largest, then red, green being comparatively small. It is stated that whereas blue and green objects are seen in the periphery before their colour can be named, a red object is seen as red as soon as it can be seen at all. This statement may be correct for certain patients, but it certainly is not universally true.

Method of taking a field

The patient sits at a table with the instrument suitably adjusted. One eye is covered. The 1° white object is used. The perimeter arm is swung into a horizontal or vertical position or into a position 30° to the one side or the other.

The surgeon keeps his attention fixed on the patient's eye, to see that he does not allow it to wander off the fixation point. He starts with the object at the end of the arm and he slowly rotates the handle of the perimeter, racking the object inwards until the patient sees it appearing in the periphery. He should not accept this as being the limit of the field, but should rack the object out a little and repeat the process at least once, in each of the first three or four positions of the arc, as it will frequently be found that on the second examination the patient will see the object at a point farther away from the centre. When the surgeon has satisfied himself that he has determined the true limit of the patient's field in this meridian, he presses the chart in the chart-holder gently against the marker, and thus records its extent at this point.

He next proceeds to rack the object slowly up to the fixation point, asking the patient to observe if it remains visible all the way, or if it appears to change, no matter how slightly, in colour or brightness. If the object is seen all the way, the surgeon turns the arc through 30° (i.e., 2 clicks of the machine), racks the object out to the extreme periphery, and repeats the process.

If, however, while being moved towards the centre the object disappears from view, it is racked back in the reverse direction until it is seen again. The point where the object is lost from view is not marked. As has already been noted, the point where the

object is lost sight of may be anything from 2° to 10° away from the point where it is seen. It is the point where it is seen that is marked.

Having marked this point, the object is once more racked up towards the centre. Since the patient has no central scotoma for white, the object must become visible again at or before it reaches the fixation point.

As has already been mentioned, if the object appears to change in colour or intensity the area over which this occurs is noted, and subsequently carefully searched for a scotoma with a smaller and possibly a coloured object.

If the field is substantially normal in size, it will be unnecessary to make more than these twelve observations.

If, however, the marks do not fall regularly near the limits of the normal field and the field shows an indentation at one point, the limits of vision at this point must be determined carefully. In order to do this the arc is rotated into the meridian of the indentation, and the object is racked to a point some 10° outside the point where it was seen. The arc is now slowly rotated in one direction, and the point where the object is seen is marked. It is then rotated in the reverse direction until the object is again seen and the place marked. The object is now racked another 10° outwards and the arc rotated once more until the limits of the field are accurately determined.

If the field is full when examined with a 1° object, and no alterations in colour or intensity are observed, nothing further remains to be done unless there is some particular indication for looking for a scotoma.

If, however, the field be found to be small, the process is repeated with a 10° object. If the field is not found to be full even when examined by this means, the surgeon moves the object backwards and forwards a degree or so along the arc to see if by this means the periphery of the retina can be stimulated. If it cannot, then the greatest limit of the field is marked. The field is next investigated with a 4° and then a 2° white object after which it is searched for scotomata with a small white object, 0.2° , or even smaller.

Then a 1° red object is employed, and if there are any indications for doing so, a smaller or larger red. Then a blue object, and lastly a green one.

The necessity for, and the importance of, moving the object slowly has already been explained. It is even more important when dealing with coloured objects than with white.

Rotation of the Arc

The method described above of rotating the arc is particularly important in determining the exact limits of a scotoma around the

fixation point, or the margins of a hemianopia and the like. If one merely determines the limits of the field by moving the object radially—in contra-distinction to rotatorily—at, say, intervals of even 15° , one does not obtain accurate results and one cannot plot out hemianopias and fields with deep re-entering angles with certainty.

As at present constructed, it is difficult to employ the Elliot scotometer except by rotating it. The result is that one obtains a very “spikey” diagram. These spikes largely disappear when the same field is worked out on a Bjerrum screen, the angles becoming rounded off as the result of taking further observations to one side and the other of the spike.

In taking a field out with a Bjerrum screen, the object can be moved in any direction. With a perimeter, it can only be moved in two, radially and rotatorily. With an Elliot it can only be rotated.

The most accurate field is most easily taken out with a Bjerrum screen, but with care an equally accurate field can be obtained with a perimeter. It requires great care to produce a chart with an Elliot that does not give the impression that the true scotoma of the disc may not be exactly the shape that is depicted.

Fatigue of Patient

Care should be taken not to fatigue the patient. If fatigued his attention will wander and inaccurate records will result, and the time both of the surgeon and the patient will be wasted.

THE THEORY OF COLOUR VISION

BY

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Concluded from p. 412.

Mr. Parsons now passes to the subject of colour vision.

III.—Colour Names

Mr. Parsons does not seem to have comprehended my view with regard to colour names though he has conceded the point for which I fought for so many years, namely, the use of colour names in a practical test for colour blindness. No one has opposed me more strongly on this point than Mr. Parsons; in fact, in the second edition of his book, 1912, he writes: “The fundamental axiom in