Flash perimetry

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The range of equipment for testing the fields of vision extends from the extremely simple requirements of the confrontation test to recently developed apparatus enabling one to examine the field by the kinetic method, to undertake static quantitative studies, and to use stimuli of varying intensities, sizes, and colours. That such a wide choice is available reflects perhaps the demand for tests which differ as regards sensitivity or purpose; for example, the test most suitable for rapid screening of large populations may not be adequate for detailed studies of the visual field in research projects. In routine ophthalmological work, however, most tests are conducted on relatively simple apparatus such as the Lister perimeter or the Bjerrum screen. These conventional methods sometimes yield unreliable results, and this unreliability is to be attributed not so much to the simplicity of the equipment as to the many possible variations in the performance of the test. The conduct of a test on the Bjerrum screen, for example, can differ from examiner to examiner according to the speed of movement of the test object, the number of meridians examined and how many times the stimulus is presented in a particular area of the field in order to check the patient’s responses. It would of course be possible to specify limits for all of these variables, and apparatus could be devised in which the speed of movement of the target could be mechanically controlled, although one would still have to choose between varying opinions as to the optimum speed of movement.

Traquair (1927) emphasized that certain factors in perimetry must be standardized, but he positively advised against uniformity in the conduct of the test, suggesting, for example, that one should choose the rate of movement of the test object “which is suited to the patient’s reaction time and gives results which show a minimum dependence on the centripetal or centrifugal movement of the object”, and that “when defects are found they must be examined with suitable tests chosen to illustrate the special features of the individual case and routine should be avoided”. Enquiry among experienced clinicians as to their opinion of the Bjerrum screen test elicits answers which range from complete satisfaction to utter distrust, and it would seem that the breadth of this opinion may well be related to the circumstances under which the test is carried out. So many variations of procedure are possible that each examiner may develop his own technique and, as a result of experience gained in doing the test himself, he develops his own criteria for interpreting the result. If he examines the same patient at a later date, the test will be carried out in a similar manner and the same criteria will be used in its evaluation; in these circumstances, it is reasonable to suppose that the test is thoroughly adequate for most clinical purposes. Difficulties arise when the clinician who has to interpret the result is unable to do the test himself but has to delegate it to some other person, whether a member of the nursing staff, a technician, or a junior clinician. This does not mean that such persons are incapable of carrying out excellent tests of the visual fields. What it does mean is that they cannot be expected to do a test on a particular patient exactly as the person

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interpreting the results would have done it, and to this must be added the practical point that persons in these categories (junior clinicians, in particular) do not remain in any one clinic indefinitely and, therefore, a patient whose fields have to be followed up over a period of years may be fortunate if he has his fields tested more than twice in succession by the same person.

If only to meet some of these practical difficulties the standardization of visual field tests should include not only physical constants, such as the level of illumination of the screen, the size of the targets, and the ambient illumination, but also the procedure to be adopted. In kinetic perimetry the speed of movement of the test object and the number of meridians over which it is moved are variables, and therefore a procedure in which stationary stimuli are presented to the patient has obvious advantages as regards standardization. Such tests already exist and can be divided into two main groups according to whether the stimuli are presented one at a time, as with the so-called Globuck screen (Buchanan and Gloster, 1965, 1966), or several stimuli are presented simultaneously as in multiple pattern tests, e.g. that of Harrington and Flocks (1954) and the Friedmann Visual Field Analyser (Friedmann, 1966; Bedwell, 1967).

The Globuck screen presents one stimulus at a time in the form of a flash which lasts for approximately one-third of a second. The stimulus is presented successively in each of 74 positions on a 1 metre square black screen, the patient being seated at a distance of 1 metre from it. The positions in which the stimulus appears have an order which is random but unchangeable, being automatically followed in each test. Provision is also made for the automatic recording of the result. In general, the results approximate to those obtained with the 2/2000 white object on the Bjerrum screen. The apparatus has been used for some years in the Glaucoma Clinic at the Institute of Ophthalmology in both the diagnosis and management of glaucoma patients, in certain research projects (Buchanan and Gloster, 1966; Tsamparilakis, 1964), and in glaucoma surveys of apparently healthy populations (Graham and Hollows, 1966; Bankes, Perkins, Tsolakis, and Wright, 1968). Its main advantages are that it is quick and simple to use, and that in our hands it has produced results which have been generally more reliable than those obtained on the Bjerrum screen; also some patients who cannot understand what is required of them in the Bjerrum screen test are able to give satisfactory results on the Globuck screen. A disadvantage is that the duration and intensity of the stimulus are difficult to standardize.

The test had shown so many satisfactory features, however, that it was decided to transfer the principle to the Goldmann perimeter, an instrument in which the stimulus intensity, background illumination, and other factors have been carefully standardized.

Methods

The investigation was concerned mainly with testing the central field of vision as far as 20° from fixation, although some work was done on the peripheral field. Fig. 1 shows the distribution of the stimuli for testing the central field, and the arrangement of the proforma for recording the results. The number of stimuli and their distribution were determined by superimposing a rectilinear grid having a mesh size of about 2.5° over the central visual field, each junction or intersection of a horizontal or vertical line of the grid together with the corners at the edge representing the position of a stimulus. Altogether there were 188 positions in which the stimulus was presented, and to this number were added twelve “blank” presentations in which the usual procedure was followed but no stimulus appeared. Thus, the total number of presentations for examination of the central field was 200. The order of the positions in which the stimuli were presented was randomized, blank presentations being included. A completely random order was not possible, however, because the four stimulus positions on the extreme left-hand side of the grid could not be reached with the arm.
of the Goldmann perimeter in the same operating position as the four stimuli on the extreme right-hand side of the grid. It was arranged, therefore, that the four extreme right-hand stimuli fell into the first half of the test, so that when this had been completed, the arm of the Goldmann perimeter could be move to the other side, the four extreme left-hand stimuli falling into the second half of the test. It was also arranged that six blank presentations should appear in each half of the test. With these exceptions the order of the stimuli was completely random.

In the early stages of the test, a grid corresponding to that shown in Fig. 1 was drawn on one of the ordinary charts for the Goldmann perimeter. The chart was fixed in position in the perimeter as usual, the horizontal lines of the grid were lettered and the vertical lines were numbered, as shown in Fig. 1, in order to identify the various stimulus positions. The operator was provided with a list giving the sequence of the stimulus positions, each of which was identified by a reference letter and number. He placed the operating lever of the Goldmann perimeter in the first position indicated on his list and presented the stimulus to the patient; then he moved the operating arm to the next position shown on his list, presented the stimulus, and so on. The patient's failure to perceive any stimulus had to be recorded on the list as the test proceeded. There were three disadvantages to this procedure:

(i) When the grid was drawn on the usual chart for the Goldmann perimeter it was extremely small, making it difficult for the examiner to place the operating arm in position accurately;

(ii) Repeated reference to the list of stimulus positions was tiring for the examiner;

(iii) The necessity of making a written record of each stimulus not seen by the patient was time-consuming.

These problems were dealt with as follows.

The operating lever of the Goldmann perimeter was joined to a pantograph (Fig. 2, overleaf), magnifying the movement about 2.5 times; the subsidiary operating arm could then be used on the type of chart shown in Fig. 1, the vertical and horizontal lengths of the entire grid being 4.5 units. The chart was mounted in a special holder so that behind it there was a metal plate perforated by 188 holes in positions corresponding to the intersections, junctions, and corners formed by the horizontal and vertical lines of the grid. An automatic projector (Hanimex La Ronde Super), surrounded by a special housing continuous with the chart-holder, was arranged so that it projected on to the back of the perforated metal plate. The projector was provided with two magazines each holding 100 slides cut out of duralumin sheet, each slide having one small perforation. The hole in each slide
was in such a position that a bright spot of light was projected on to one of the holes in the perforated metal plate, forming an illuminated spot on the chart which indicated where the operating lever should be placed for the next stimulus to be flashed. When this stimulus had been presented the examiner used the trigger on the hand control unit (Fig. 3) and this activated the automatic projector to move on to the next slide; the latter had a hole in another position and so indicated the position for the next stimulus. The chart was covered by a perspex plate also having 188 holes corresponding to the position of the stimuli. Each of these holes provided a locking position for the peg on the hand control unit; as soon as the spot of light indicated the position of the next stimulus, the examiner removed the peg from the previous hole and placed it in the next hole as indicated by the light. He then flashed the stimulus, and when the patient indicated he had seen the stimulus the examiner pressed the trigger on the hand control unit again, the automatic projector indicated the position of the next stimulus, the examiner moved the peg of the control unit to that position and
presented the stimulus. Whenever a patient failed to perceive a stimulus, the examiner pressed the push-button on the control unit with his thumb and this punched a small hole in the chart in the corresponding position. The order in which the slides were put in the projector was determined by the randomized order of the stimuli as previously described; twelve unperforated slides, corresponding to blank presentations, were included in the series. In order to save space the automatic projector did not project directly on to the back of the perforated metal plate of the chart holder but its beam was deflected through 45° by a mirror as shown in Fig. 4.

![Fig. 4](image)

**FIG. 4** Mechanism indicating position of stimuli

- P = projector;  
- D = drum for slides;  
- M = mirror;  
- C = control unit

The flashing stimulus was provided by a small electro-magnetically operated shutter near the projection lamp of the Goldmann perimeter, the shutter being operated by a foot control. The duration of the flash, which was almost a square pulse, was 0.3 sec., as measured with a photomultiplier and suitable recording equipment.

For the examination of the peripheral as well as the central field on the Goldmann perimeter by the flash method, it was decided to use positions of the stimulus (Fig. 5, overleaf) corresponding to those suggested by Esterman (1967) as being most useful in attempting to describe quantitatively the extent and significance of a field defect. The extent of the peripheral field examined did not permit the use of the pantographic arrangement nor the device indicating the sequence of stimuli, and therefore for the peripheral field the examiner had to return to the former method of using a list of stimulus positions. In some later tests, in order to accelerate the procedure, the stimuli were presented sequentially as they appeared in rows on the chart, starting from the top left-hand corner and working down to the bottom right-hand corner.

Most of the tests were carried out with the 1.4 or 1.3 target but some patients gave satisfactory results with 1.2. It is to be borne in mind that, when presented as a flash, a target of a particular size cannot be regarded as providing a stimulus of an intensity equal to that given when it is used in the ordinary way in kinetic perimetry. It was generally found that a given target presented as a flash gave a smaller field of vision than when it was presented continuously in the kinetic method. If
necessary, the patient wore his correction for near work. Adjustment of the patient’s position and adaptation to the general level of illumination were carried out using the routine recommended for ordinary kinetic perimetry on the Goldmann perimeter.

Most of the patients examined were drawn from the Glaucoma Clinics of the Institute of Ophthalmology and the City Road branch of Moorfields Eye Hospital. The majority of tests were carried out by one examiner. Some patients were also examined on the Bjerrum screen, on the Globuck screen and on the Lister perimenter.

**Results**

Examination of the central field usually took 10 to 15 minutes for each eye. The majority of patients did the test satisfactorily but a few remarked that it was extremely tiring or confusing or that it required a great deal of concentration.

A typical result from a patient with a normal field is shown in Fig. 6, which shows that out of the 188 stimuli presented, only six were not seen by the patient and these formed a

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**Fig. 5** Position of stimuli presented for examination of peripheral as well as central field.

**Fig. 6** Normal central field Mr. F. C. 4/68
compact group fitting exactly the expected position of the physiological blind spot. Bearing in mind that the stimuli were presented in a completely random order it is reasonable to look upon this sort of result as proof of the excellence of the patient's fixation, concentration, and cooperation. Further information about the reliability of the patient's performance is given by the responses made to the twelve "blank" presentations which were scattered randomly throughout the series of stimuli presented.

Patients who were not quite as reliable but who had normal fields produced results similar to that shown in Fig. 6, but with a few stimuli in the area of the physiological blind spot recorded as having been seen and two or three stimuli at 20° eccentricity having been missed.

Figs 7, 8, and 9 illustrate typical results obtained from glaucoma patients. Fig. 7 shows an upper and Fig. 8 a lower arcuate scotoma, while Fig. 9 shows the combination of an upper and lower arcuate scotoma.

**FIG. 7** Upper arcuate scotoma Mrs. J. B. 2/69

**FIG. 8** Lower arcuate scotoma Mrs. F. B. 2/69

**FIG. 9** Upper and lower arcuate scotomata Mr. W. B. 10/68

**FIG. 10** Early defect in a myope with glaucoma, in whom no defect was apparent on the Bjerrum screen Mrs. F. B. 6/68
Fig. 10 illustrates the field found at the first attempt with this method on a myopic patient who was suspected of having simple glaucoma, because her intraocular pressure was slightly raised and the ophthalmoscopic appearances of the discs were suggestive of glaucomatous cupping, but in whom two previous examinations on the Bjerrum screen by competent examiners had failed to reveal any defect in the visual field: the defect in this patient later became more marked (Fig. 8).

Fig. 11 illustrates the extensive loss of the upper field in a glaucoma patient when the peripheral field was tested as described above.

Tests have been repeated at intervals of several months on a number of patients and the general impression has been that the consistency of the results is high. In a few patients in whom repetition of the Bjerrum screen tests showed great variability in the size and shape of the recorded field, repeated tests with the procedures described above gave results which were far more consistent than those obtained on the Bjerrum screen.

Discussion

Judging from the results over a period of about 18 months the aim of producing a standardised procedure for examination of the central field has been at least partially achieved. Most of the tests were in fact carried out by one examiner but substantially similar results were obtained by a deputy; nevertheless, the variability from one examiner to another needs to be evaluated further as also does the consistency of the procedure relative to that of existing tests such as the Bjerrum screen.

The inclusion of “blank” presentations is useful for checking the reliability of the patient’s responses and also has the advantage that one can warn the patient of their existence so that he does not automatically report seeing a stimulus every time he hears the shutter mechanism operating. Even better confirmation of the reliability of the patient’s performance is given by the finding of clearly demarcated physiological blind
Flash perimetry spots and the provision of stimuli in the region of the blind spot is of undoubted value for this purpose in tests of this type.

In its present form the apparatus possesses considerable versatility in that it is a relatively simple matter to change the sequence in the automatic projector. For detailed coverage of the central area of the visual field it is doubtful if the number of stimulus positions could be reduced, but this may not be so if the aim is to detect a particular type of defect. From an analysis of the results obtained on 25 eyes in which arcuate scotomata were found, a shorter programmed sequence of stimuli has been developed for the detection of an upper or lower arcuate scotoma. For this purpose it seems that only 48 presentations of the stimulus are required, their positions being shown in Fig. 12. As with the full version of the test, a random order of presentation is used. In a small series of patients examined so far no arcuate defects evident on the full test have been missed with the shortened procedure.

The method seems to provide a suitable way of following up the visual field in glaucoma for research purposes and perhaps for routine clinical work, but the general significance of the results is to be related not so much to the apparatus and the actual procedure as to the principle of recording the visual field by means of flashed stimuli presented randomly in different positions. For further improvement it would be worthwhile to explore other methods of achieving this without the need for manual adjustment of the position of the stimulus and with the provision of automatic recording.

Summary

The sources of error in kinetic perimetry are discussed briefly and it is pointed out that some of the errors can be avoided by presenting the stimuli as flashes in fixed positions in the visual field. A method of achieving this, using the Goldmann perimeter, is described. With glaucoma patients the results of this test were more reliable than those obtained on the Bjerrum screen.

There are two people who have helped greatly in the development of this test and whose assistance has been invaluable. They are Mr. D. Poinosawmy who carried out the tests with the greatest patience and skill and Mr. C. Downing who constructed the apparatus and has given much helpful advice regarding its design.
References

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