STATIC PERIMETRY — A PSYCHOPHYSICAL TEST

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* *The work being carried out with static perimetry in the Retinal Dystrophy Service clinic at the University of N.S.W. has been made possible through the generous donation of the The Lions' N.S.W. — A.C.T. Save Sight Foundation.*

Abstract
The physical factors contributing to the definition of static perimetry as a psychophysical test are linked to the physiological background and comment is made on their clinical significance. The psychological factors are noted and the value of the test is briefly stated.

Key Words
Static perimetry, psychophysical, physiological, quantitative, threshold, Goldmann, technique.

Perimetry shows the relationship between physical characteristics of the stimulus and the psychological or perceptual response by the subject.

Kinetic perimetry attempts to locate the boundaries of the visual field and the areas within that are sensitive to preselected moving test objects. Static perimetry attempts to find the sensitivity of the retina at preselected locations with stationary objects, thus giving a retinal profile[1] through the mountainous visual island i.e. a vertical section of threshold values along a chosen meridian.

Hecht, Schlaer and Pirenne[2] in 1942 reported an experiment in which they found the lowest intensity of interrupted light flashes that the normal human eye could see i.e. threshold intensity. It is on such early experiments that current methods of testing by static perimetry are based.

PHYSICAL FACTORS AND PHYSIOLOGICAL BASIS

In order to understand the value of static perimetry and realize the need for accuracy in technique a knowledge of the relevant interrelated physical, physiological and psychological factors is necessary. Therefore in the following paragraphs the PHYSICAL and PHYSIOLOGICAL factors involved have been linked and their clinical application noted. The psychological factors are discussed separately.

(1) Luminosity of target and threshold at locations on the retina

The relationship between the sensitivity of the retina to light and the location of the stimulus on the retina is examined in static perimetry. In the normal subject the graph of the sensitivity to light is affected by the distribution of the rods and cones with the influence of the rods increasing as the target moves peripherally. (Compare fig. 1 with photopic graph in fig. 3).

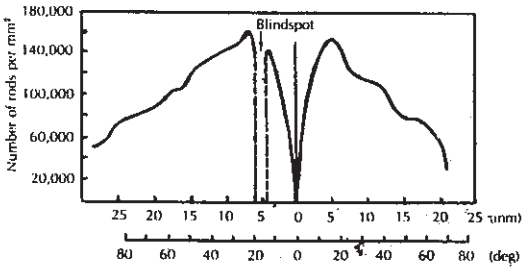

Figure 1. Rod density along horizontal meridian of right eye. (After Pirenne, "Vision and the Eye" (1967) p.32)

Threshold is considered reached when the subject responds 60% of the time.[2] Hecht and his co-workers queried: Why does the subject not respond 100% of the time when the intensity of the target is set at threshold? They concluded this was a consequence of the physics of light itself and that the subjects' judgements are particularly consistent.

The commonly used bracketing or staircase technique is the most accurate for approaching and finding threshold[3] i.e. the target is alternatively presented at supra and sub threshold levels until a mean is reached at which the subject responds at

least 3 out of 5 times to a set target luminosity at one selected location. Errors are smaller with this technique than with "the method of limits" (gradually ascending steps from sub-threshold) although short and long term effects of threshold fluctuations are still present.[4]

The patient is advised as to the approximate location of the target in order to minimise some of the psychological factors to be mentioned.

Local adaptation of the retina is avoided by allowing an interval of at least 2 seconds between the interrupted presentations of the stimuli after there has been an affirmative response.

The number of locations to be tested must be limited by practical considerations, such as fatigue, and one meridian should take no longer than about 15 mins. A suspicious area can be ascertained initially by kinetic perimetry and the required meridian(s) then selected for static testing. (see fig. 2)

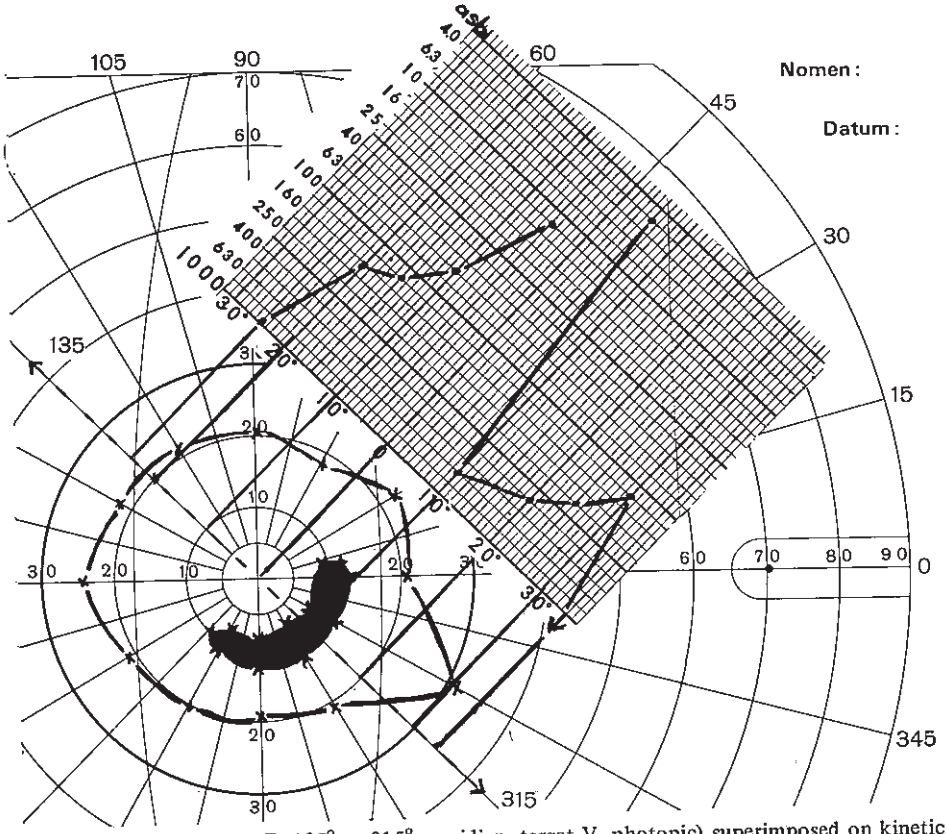

Figure 2. Static perimetry graph (RE, 135° – 315° meridian, target V, photopic) superimposed on kinetic field (target V4e). The defect is more thoroughly quantified by static examination.

(2) Background illumination and state of adaptation.

Scotopic testing takes place with the background illumination totally extinguished after the subject has been fully dark adapted. Illumination is increased to 10 asb for mesopic conditions and 31.5 asb for theoretical photopic conditions on the Goldmann perimeter. An apostilb is a unit of light measurement.

Dark adaptation is a phenomenon that is still not fully understood but clinically its effect in the normal is to lower the threshold of the visual elements dramatically, particularly of the rods, and enhance contrast. There is a slight shift in sensitivity towards the blue end of the spectrum. The state of adaptation will therefore have a marked effect on results obtained. (see fig. 3)

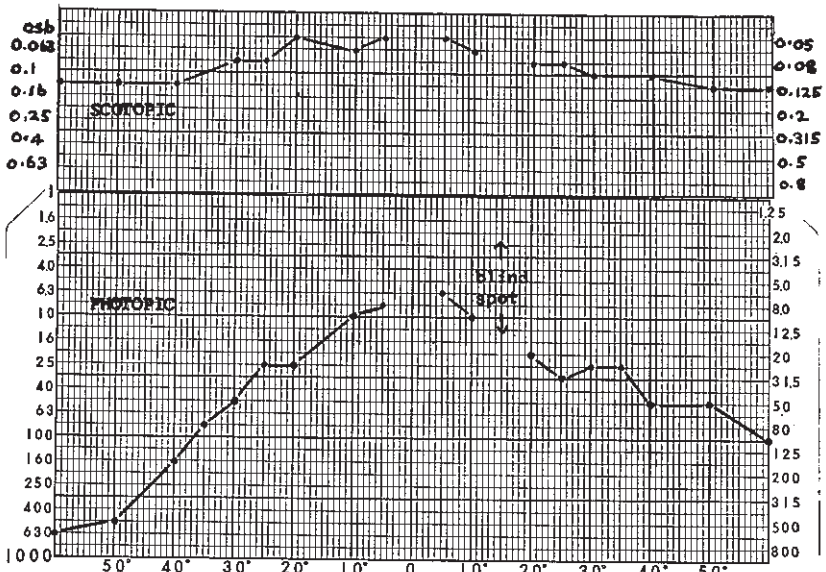

Figure 3. Normal scotopic and photopic static perimetry results.

(3) Colour of target and colour perception.

It must be remembered that four different responses can be elicited from a patient undergoing colour perimetry:

a) movement is seen (in kinetic perimetry)
b) an object is seen with no colour
c) an object is seen with a difference in the saturation of the colour
d) an object is seen with the correct colour.

The amount of stimulus produced by a target is a product of its size and luminosity. In perimetry it is usual to test with coloured targets larger than the white targets as the purpose is to stimulate a larger area of the retina with a reduced intensity.

As colour is a subjective sensation it is very difficult to standardize results accurately. The use of monochromatic light as from a laser would be an advantage.

(4) Size of target and spatial summation.

A single quantum is sufficient to activate a rod and the effect on nearby rods is added up by the visual system. A quantum is an indivisible packet of light energy. As a greater number of rods will be stimulated an increase in the size of target therefore increases its stimulus value.

Spatial summation increases with distance from the fovea and is greater for rods than cones, but inversely there is a gradual decline in sensitivity to size and brightness peripherally, with a decrease in receptor density.

On the Goldmann perimeter a scale of stimuli values has been calculated[5] for the relationship of target size to the neutral density filters, with background illumination of 31.5 asb. This simplifies the expression of quantitative perimetry which has increased in complexity from Goldmann's original concept. It is based on the graded steps of the three sets of filters in which the density markings =, – , no bar = descending steps of 2 lot units, markings 1,2,3,4 = steps of 0.5 log units, markings a,b,c,d,e = steps of 0.1 log units.

(5) Presentation time and temporal summation.

It was found that a flash shorter than 0.1 second duration had no effect on threshold.[2] Therefore to ensure the activation of temporal summation and so ensure that threshold contrast is independent of presentation time a minimum time longer than this should be adopted. With allowances made for psychological factors, such as alertness, it is advisable to have a presentation time of 0.5 to 1 second for clinical perimetry.

(6) Pupil size and retinal adaptation.

The size of the pupil only theoretically affects the extent of the visual field. However it has a slightly more significant effect on the illumination of the retina, the brightness of the retinal image and the resolving power of the eye. So, for absolute accuracy, photopic perimetry should be avoided when the pupil is dilated.

(7) Refractive error and resolution.

According to present data there is negligible

effect of blur on perimetric threshold from 35° to the periphery. Consequently the refractive correction for the testing distance (30 cm.) should be added from 0° to 30° as in kinetic perimetry.

(8) Age of patient and retinal sensitivity.

Dark adaptometry and kinetic field testing both show slight changes in standard variation according to age. This could therefore be expected with static perimetry and is being investigated further at present.

PSYCHOLOGICAL FACTORS

The psychological factors which abound in a clinical situation inevitably affect perimetric accuracy. Recognition of these factors and adaption of one's technique to avoid their influence as much as possible is the responsibility of the perimetrist.

Alertness, co-operation, understanding, motivation and freedom from anxiety are desirable qualities to stimulate in the patient. So often, instead, one is confronted with fear of the diagnosis of disease, fear of responding incorrectly, over-anxiety to please, fatigue and inattention due to the age of the patient, effect of drugs and maybe preoccupation with hunger, thirst or time.

Objectivity and accuracy should be paramount. These are best attained through careful explanation to the patient of the requirements and emphasis that alertness will trigger off some false responses which the perimetrist will be prepared to eliminate. Fixation must be checked continually. Under scotopic conditions the infra-red beam or similar attachment would be invaluable but otherwise periodic excursions into the blind spot region can help check fixation.

VALUE

The value of static perimetry lies in:—

a) the quantifying of defective as well as apparently good areas of vision in the field which has previously been examined by kinetic methods.
b) the precise recording of slight changes in the visual field which can be made with serial examinations in order to follow the progress of a disease.

It is a sensitive form of testing for both diagnostic and prognostic purposes. If one realizes the truth of the statement "the diagnosis of an observed scotoma is always a statistical decision and not an absolute matter"[6], the value of static perimetry becomes apparent.

CONCLUSION

It has been shown that a number of interrelated factors influence the accuracy of static perimetry results. These results should be assessed, for diagnostic and prognostic purposes, against the standard deviation.

Ideally the statistical data for this are obtained from the same clinical environment as that in which the abnormal is examined, that is the one in which these factors are all in force.

A skilled perimetrist will combine constancy of method, understanding of the psychophysical factors described here and understanding of the defect to be investigated and is thus capable of obtaining accurate, reproducible retinal profiles which can be assessed in relation to the normal and to subsequent recordings.

The value of automated static perimetry is evident[7] but must be weighed against that of an experienced perimetrist who is also capable of other skills in an ophthalmic practice or clinic.

Acknowledgement

My thanks are due to Dr. Frank Halliday, Director of the Retinal Dystrophy Service, whose expertise and assistance have motivated my interest in this subject.

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