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Variability of the hill of vision and its significance in automated perimetry*

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SUMMARY It has been assumed that the retinal threshold sensitivity profile is a standard which decreases predictably with age. On this basis the significance of relative scotomata is decided on certain types of perimeter. The hill of vision was measured in 128 healthy eyes on the Dicon 2000 autoperimeter. We found a large variation between individuals, with no relationship to age. The relevance of the findings to automated perimetry are discussed.

Automated static perimeters screen the visual field at selected points. They may establish the threshold sensitivity at each point and compare it to an assumed age related value, as is the case with the Octopus.[1] Otherwise a stimulus greater than the assumed normal threshold value is used on the premise that any missed point shows a significant defect. The suprathreshold technique developed by Armaly[2] on the Goldmann perimeter, and later modified,[3] has the advantages of speed and reproducibility in the hands of different operators.[4] It is used on many automated perimeters, including the Fieldmaster,[5] the Friedmann,[6] and the Dicon. The Fieldmaster uses two levels of suprathreshold stimulus, the stronger one beyond 30° of eccentricity. In the case of the Friedmann the threshold is not assumed but is determined for each patient; however, the shape of the hill of vision is assumed.

The Dicon perimeter measures the individual profile by simultaneous stimulation in four quadrants at equal eccentricity under photopic conditions. This circumvents possible error due to local field defects. Glaucoma screening is then performed at 0·4 log unit (LU) suprathreshold. We discuss the measurements from 128 such hills of vision and their implications on automated perimetry.

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Table 1 *Description of age groups*

Group	*Age range (years)*	*Visual acuity range*	*Number of subjects*
I	9–29	6/5–6/6	20
II	30–49	6/5–6/9	20
III	50–80	6/5–6/12	20

Materials and methods

The hill of vision was measured on the Dicon 2000 automated perimeter with a background illumination of 31·5 apostilbs (Asb) and a spot size Goldmann II. Threshold was determined by simultaneous stimulation in four quadrants along the 45°, 135°, 225°, and 315° meridians at equal eccentricities of 2·5°, 5°, 15°, 25°, 40°, and 60°. A semibracketing technique is used where alternative stimulation above and below threshold in decreasing steps is concluded by a double confirmation to a resolution of 0·2 LU.

Our 128 subjects were drawn from members of staff at the Manchester Royal Eye Hospital and patients attending its Accident and Emergency Department with a visual acuity of at least 6/12 in their healthy (tested) eye. Of these subjects 60 were grouped according to age (Table 1). One eye per subject was tested, with a reading correction when applicable.

Results

The hill of vision may be described in three parts: the central peak, the mid-plateau from 15° to 25° eccentricity, and the peripheral decline. The components of 128 hills of vision were analysed with reference to the central peak height, the threshold sensitivity of the mid-plateau, and the degree of peripheral decline (Fig. 1).

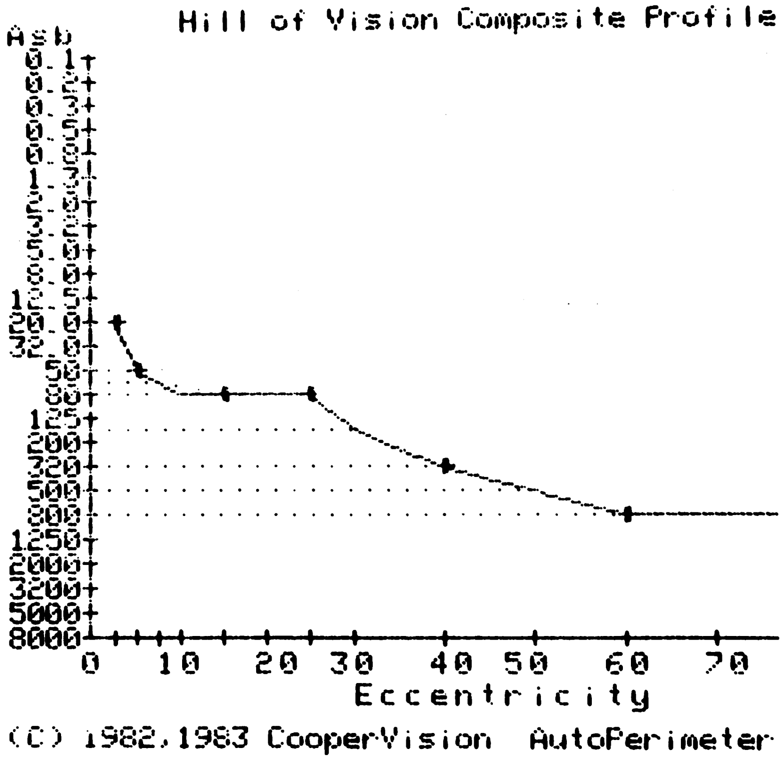

Fig. 1 *A typical hill of vision described in three parts: the central peak, the mid-plateau from 15° to 25°, and the peripheral decline.*

The central peak height (Fig. 2). Its height was taken from the level of the mid-plateau at 15° eccentricity, and it showed a flat distribution over a range of 0 to 1·0 LU. The largest group of 43% was found at 0·2 LU.

The mid-plateau threshold sensitivity (Fig. 3). For this measurement we used the sensitivity at 15° in all cases. Although 37·5% of plateaus were sloping, only two fell by more than 0·4 LU. The plateau sensitivity was concentrated, giving a sharp distribution with 89% of values found in the 50 and 80 Asb groups.

The degree of peripheral decline (Fig. 4). The drop in sensitivity from 25° skewed to the left over the range 0 to 1·8 LU. Although the first group (0 to 0·4 LU) was the largest at 57%, 13% of declines were greater than 1·4 LU. Only four subjects showed no decline.

The relevance of age to the hill of vision was assessed by comparing three groups (Table 1). The average peak height for each group was found to be

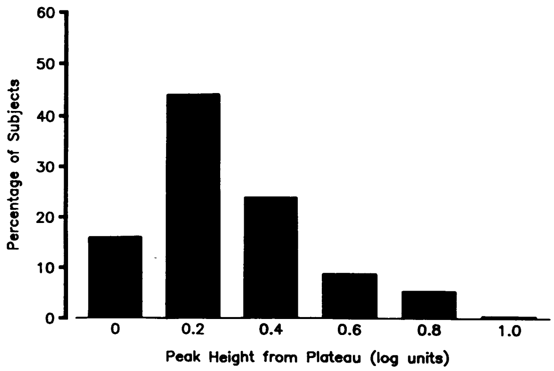

Fig. 2 *The central peak: distribution according to height in 128 subjects.*

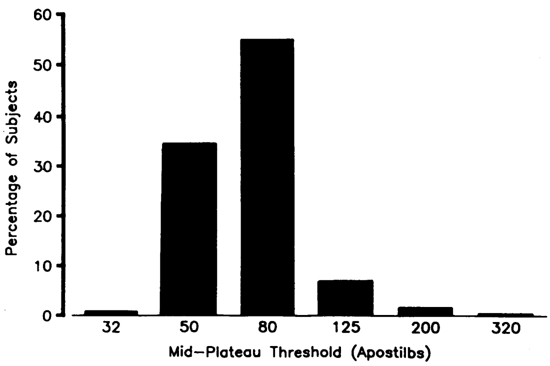

Fig. 3 *The mid-plateau: distribution according to threshold sensitivity in 128 subjects.*

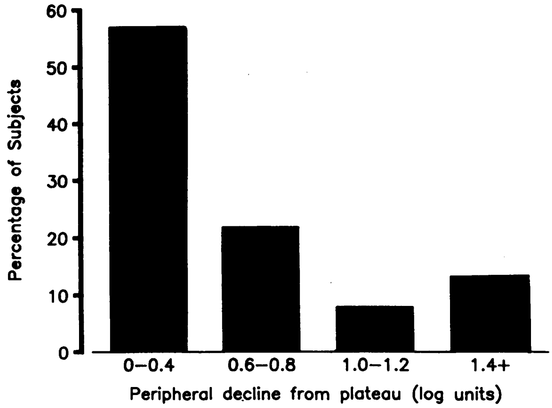

Fig. 4 *The peripheral decline: distribution according to degree of fall in 128 subjects.*

highest in group II and lowest in group III (Table 2). Looking at the mean value of the mid-plateau threshold for each group, taken between the 15° and 25° sensitivities, we found no significant difference between groups. The highest value was found in group III. However, variation within groups showed a decrease with age.

Discussion

In deciding the significance of relative scotomata many automated perimeters must refer to standard values of threshold sensitivity and characteristics of profile deemed normal. Our findings show surprisingly large differences in both these respects among individual hills of vision. Both the central peak height and the degree of peripheral decline varied markedly

Table 2 *The central peak height and mid-plateau threshold: correlation with age*

Group	*Average central peak height from plateau (log units)*	*Average mid-plateau threshold with standard deviation (Asb)*
I	0·38	67·9±18
II	0·43	66·0±14
III	0·28	70·2±12·8

(Figs. 2, 4). Although the mid-plateau sensitivities showed less variation (Fig. 3), it was significant, especially in view of the fact that 37·5% of plateaus were sloping. The results of subjects grouped by age (Table 2) failed to demonstrate any loss of sensitivity with increasing age. One subject aged 80 had a mid-plateau threshold of 50 Asb, whereas another aged 9 had one of 65 Asb.

The concept of a hill of vision of uniform profile which decreases in sensitivity with increasing age is erroneous. Accurate perimetry depends on combining a high sensitivity (minimal false negatives) with a high specificity (minimal false positives). Variation from an assumed 'normal' in threshold related testing will give reduced specificity where threshold is above that expected and reduced sensitivity where it is below. In suprathreshold testing, which assumes a 'normal', the degree of suprathresholdness can be increased to maintain specificity at the cost of reducing sensitivity.

By tailoring the suprathreshold stimuli to the individual hill of vision it should be possible to maintain a high specificity with a minimal degree of suprathresholdness and hence a minimal loss of sensitivity.

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