THE EFFECT OF STIMULUS DURATION UPON THE COMPONENTS OF FLUCTUATION IN STATIC AUTOMATED PERIMETRY

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SUMMARY

We studied the effect of varying the stimulus duration time on the components of fluctuation in static automated perimetry by testing 20 healthy subjects on the Humphrey Field Analyser within the central 20° of vision. We found the total fluctuation at a stimulus duration of 0.065 s, to be 3.22 decibels (dB); 0.1 s, 3.22 dB; 0.2 s, 3.34 dB; 0.3 s, 2.95 dB; 0.4 s, 3.24 dB; and 0.5 s, 3.22 dB. Little difference was observed in the individual components (short-term, long-term homogeneous, long-term heterogeneous and inter-individual) or total fluctuation with an increasing stimulus presentation time when evaluated over the entire visual field or in a pointwise fashion. This study suggests that the stimulus duration within the range of times studied has little effect on the components or total fluctuation in healthy individuals.

Values for threshold obtained from automated perimetry are used to diagnose glaucomatous visual field defects and determine their progression. Unfortunately, the accuracy of a visual field exam may be limited by fluctuation between individual measurements for threshold. Finding techniques which reduce variation would increase the reliability of individual threshold measurements and improve the accuracy of automated visual field interpretation. We studied the components and total fluctuation in normal individuals tested on the Humphrey Field Analyser using different stimulus presentation times to determine the effect upon threshold variation.

MATERIALS AND METHODS

We included in this study healthy individuals with 20/20 visual acuity who worked at the Medical University of South Carolina. We used normal subjects to evaluate

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threshold variation as suggested by previous authors.^{1,2} Each subject had had at least one previous automated visual field examination. We excluded individuals who had retinal or neurological disorders as well as media opacities which might have influenced the visual field. Each subject was tested with their best corrected refraction and had a pupillary diameter of at least three millimeters (mm). Informed consent was obtained after the nature of the procedure had been fully explained.

We studied each subject on the Humphrey Field Analyser which is a single unit projection perimeter with a 330 mm bowl. Fixation is monitored by an occasional stimulus projected into the blind spot. If the subject fails to perceive this stimulus, then proper fixation is assumed. Fixation also may be checked directly by the technician.

We tested each individual with a customized visual field examination which included 30 locations spaced 8° apart located 16° on either side of the horizontal midline and 20° either side of the vertical midline. A similar region of the visual field was tested by investigators who previously have studied the components of fluctuation.³⁻⁵ We tested one randomly selected eye from each subject twice with the customized visual field examination within a half hour time period. We then completed a similar session of two visual field examinations on a separate day within two months. These two sessions were performed for each presentation time evaluated in this study which included in the sequence tested: 0.065, 0.1, 0.2, 0.3, 0.4, and 0.5 seconds. Each subject was randomised to begin the sequence at a different stimulus duration. The times evaluated reflected stimulus durations both shorter and longer than either the 0.1 or 0.2 s times used previously to describe the components of fluctuation.^{3,6} In total 480 visual field examinations testing 14,400 locations were performed for this study.

The components of fluctuation were calculated according to the nested model of Graybill.⁷ This model identifies four components of fluctuation: the short-term component represents the fluctuation within a single testing session. The long-term homogeneous component represents the

Table I. Mean threshold level time studied across all subjects and locations for each stimulus presentation

Time interval (seconds)	Decibels	Apostilbs
0.065	30.4	9.12
0.1	30.8	8.32
0.2	31.7	6.76
0.3	32.4	5.75
0.4	32.6	5.50
0.5	32.9	5.13

uniform fluctuation between testing sessions. The long-term heterogeneous component shows the non-uniform fluctuation among locations between testing sessions, and the inter-individual component represents the fluctuation observed between subjects tested. The pointwise fluctuation (including short-term, long-term homogeneous, and inter-individual components) also was calculated to show the influence of location on the variation of threshold measurements. In addition, the mean threshold level across all subjects and locations was calculated for each presentation time studied.

RESULTS

We included in this study 20 healthy subjects with an average age of 23.9 ± 2.9 (range 17–32) years. Thirteen subjects were male and seven female; 18 were white and two Asian.

The mean threshold level for each stimulus duration studied is shown in Table I. The mean threshold sensitivity approximately doubled between 0.065 s and 0.5 s, although 84% of the sensitivity increase occurred between 0.065 s and 0.3 s.

The components of fluctuation for each presentation time are shown in Table II. No obvious trends were observed in threshold fluctuation when lengthening the presentation time from 0.065 s to 0.5 s. The pointwise fluctuation is shown in Figure 1. No apparent differences were observed across the different stimulus durations studied except an increased pointwise variation in the inferior visual field when using the 0.5 s stimulus.

DISCUSSION

The probability of a stimulus being perceived apart from its background depends on, among other factors, the background illumination as well as the intensity, size, and presentation time of the stimulus. Typically, in automated perimetry all these factors are held constant except the

Table II. Components and total fluctuation for each stimulus presentation time studied

Component:	Fluctuations in decibels					
	0.065s	0.1s	0.2s	0.3s	0.4s	0.5s
Short-term	1.92	1.95	2.03	1.59	1.81	2.27
Long-term homogeneous	1.48	1.08	1.04	1.43	0.97	0.06
Long-term heterogeneous	1.84	2.15	2.23	1.68	2.24	2.03
Inter-individual	1.06	0.88	0.94	1.15	1.10	1.03
Total fluctuation	3.22	3.22	3.34	2.95	3.24	3.22

Fig. 1. Pointwise fluctuation for each stimulus duration studied. Locations are separated by 8 degrees and are located to 20 degrees on either side of the vertical midline and 16 degrees on either side of the horizontal midline.

intensity of the stimulus. Therefore, the ability of a patient to perceive a stimulus should depend on the differences between the background and stimulus intensities.

However, the smallest difference between the background and the stimulus intensities a person perceives fluctuates over time which creates uncertainty in measuring threshold. Therefore, finding techniques which reduce fluctuation may improve the reliability of an automated visual field examination. One previous study found no advantage in reducing fluctuation using stimulus sizes apart from the Goldmann size III, which is used most commonly in automated perimetry testing.⁸ Similarly, another report was found no benefit in using a low or high mesopic background intensity in reducing fluctuations as opposed to the low photopic intensities (4 or 31.5 apostilbs [asb]) most commonly used in automated perimetry testing.⁹

A separate report found slightly reduced short-term and long-term heterogeneous components of fluctuation while testing normal individuals on the Humphrey Field Analyser compared to the Octopus perimeter. The Humphrey displays a stimulus for 0.2 seconds and has a background illumination of 31.5 asb while the Octopus presents a stimulus for 0.1 seconds and has a 4 asb background. The different testing strategies of these two perimeters could have contributed to the lower reported fluctuations on the Humphrey. However, the reasons for the difference in fluctuations were not explored in this study⁶ and may have resulted from a testing artefact based on the separate thresholding techniques between the two perimeters.¹⁰

This study differed because we evaluated the effect of altering the stimulus duration upon the components of fluctuation.

Using manual perimetry a stimulus has been shown to be easier to perceive (temporal summation), as described by Bloch's law, up to between 0.06 and 0.2 seconds in duration. Longer presentation times decrease little the stimulus intensity which a subject may perceive. Generally, static threshold testing is performed with a stimulus duration long enough not to be influenced by temporal summation, but short enough to not stimulate a saccadic ocular movement which may occur after 0.25 seconds.^{11,12}

This study showed that changing the stimulus presentation time from 0.065 s to 0.5 s has little effect on the components or total fluctuation. Pointwise variation was similar across all presentation times except for increased variation in the inferior field when using a 0.5 s stimulus. The reason for this increase is unknown and may be artefactual. This study also confirmed previous reports using manual perimetry showing little influence from temporal summation with stimulus presentation times greater than 0.3 sec. The components of fluctuation were slightly increased in our study over those observed in previous reports.^{3,4,8,9}

This study suggests little benefit in reducing threshold variation in healthy individuals by altering the stimulus duration from the 0.1 or 0.2 sec used previously to study the components of fluctuation.

This study does not indicate if altering the stimulus presentation time may be a benefit in glaucoma patients or elderly individuals. Threshold variation has been shown previously to be greater in these groups of patients when compared to young healthy subjects.^{4,13} Also, the results of this study may have differed if another automated perimeter with a different thresholding technique was used. Potentially altering other testing parameters such as using a coloured or a pattern discrimination stimulus may help stabilise threshold variation and improve the reliability of automated perimetry.

Key words: Automated perimetry, glaucoma, stimulus presentation interval, threshold variation.

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