Balanced luminance multifocal pupillographic perimetry

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PURPOSE: To investigate 4 variants of multifocal pupillographic perimetry in glaucoma to further explore the effects of balancing the stimulus luminances across the visual field to match the sensitivity of the pupillary field.

METHODS: Following a smaller scale experiment (Kolic et al. 5280/A210) we tested 40 normal and 39 glaucoma subjects to further explore the effects of luminance balancing. All eyes were examined with HFA achromatic, SWAP and Matrix 24-2 perimetry and Stratus OCT. Visual fields were classified by HFA mean defects: moderate: 6 to 12 dB, severe: >12 dB. Glaucoma subjects had a moderate or severe visual field in at least one eye. All subjects gave informed written consent. Multifocal stimuli having 44 test regions/eye, extending to 30 deg eccentricity, were presented concurrently to both eyes using a prototype of the TrueField Analyzer (**Fig. 1**). Recording duration was 4 minutes, divided into 8 segments of 30 s. Pupil diameter was monitored under infrared illumination. The 4 stimulus protocols examined differed in terms of mean presentation intervals (MPI) of 1 or 4 s per region, and balancing strategy **(Fig. 2**, **Table 1**). The balancing strategies assumed stimulus/response functions of the form $R=S^z$ where z was 0.5 or 0.66. The peak test luminances were 150, 290 or 340 cd/m^2. The backgrounds were 10 cd/m^2. Almost all eyes were tested twice with the 4 stimulus variants. Diagnostic performance was assessed by areas under ROC curves (AUCs) for the N-worst response amplitudes.

RESULTS: For all visual field severities the best AUCs were produced by a stimulus having MPI=4 s, luminance 150 cd/m2 and z=0.5. For severe fields the mean of the 20 regional amplitudes that most deviated from the normative data gave an AUC of 0.984 ± 0.008 (mean ± SE), and for combined moderate and severe fields 0.858 ± 0.038 (**Table 2**).

CONLUSIONS: Careful balancing of the stimuli to cater to differences in field sensitivity, minimized the effects of response saturation, as characterized by the exponent z, and improved the diagnostic efficiency of pupillographic multifocal perimetry. The pupillographic method eliminates several problems associated with conventional subjective perimetry.

Figure 1. TrueField Analyzer . Can be seen at trade booth 822

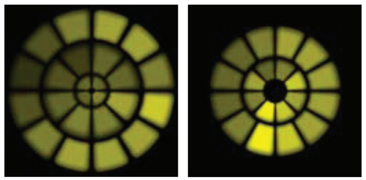

Figure 2. Example of the luminance balancing of protocols where z = 0.5 (Table 1, top right). The stimuli illustrated are the 44 that would be resented to the left eye, the right eye stimuli were left right mirror symmetric.

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protocol	Mean Presentation Interval(s)	Max Luminance	Balancing exponent	Median t-stat normal	Median t-stat glaucoma
P117	1	290	0.5	2.64	2.32
P118	1	340	0.5	2.86	2.40
P119	1	340	0.67	2.60	2.25
P120	4	150	0.5	2.98	2.43

Table 1. The three right columns give the differences between the four experimental protocols in terms of their mean presentation interval (MPI) in seconds/presentation/region; maximum luminance and the balancing exponent. The left 2 columns give the median t-statics for the normal and glaucoma subjects. Medians were computed across regions, pupils, eyes and subjects

Severity	N eyes	Stimulus Protocols			
		P117	P118	P119	P120
All	154	65.2 ± 3.1	68.0 ± 3.0	66.5 ± 3.1	67.6 ± 3.0
Mild	109	60.0 ± 3.7	61.5 ± 3.5	60.6 ± 3.6	61.7 ± 3.6
Moderate	25	71.0 ± 6.7	74.4 ± 6.2	73.7 ± 6.1	**75.8 ± 6.1**
Mod + Sev	45	81.1 ± 4.3	83.8 ± 3.8	82.0 ± 3.9	**85.8 ± 3.8**
Severe	20	93.9 ± 2.0	96.3 ± 1.5	92.4 ± 2.8	**98.4 ± 0.8**

Table 2. Percent area under ROC plots ± SE for the 20 worst regional deviations from normal for constriction amplitudes, shown by visual field severity. Mild defects HFA MD 0 to -6 dB, moderate MD -6 to -12 dB, severe fields MD worse than -12 dB. There were 160 normal eyes included.

Summary: The objective pupillographic method eliminates several problems associated with subjective testing as employed in conventional automated perimetry. Some relevant features are:

- The test is about twice as fast as current perimeters
- The visual fields of both eyes are measured concurrently and independently providing a good statistical basis for comparison between the fields of the two eyes
- Direct and consensual responses of the pupils are measured concurrently, so only one operating pupil is required to do the fields of both eyes, and information about afferent and efferent defects is obtained in all points in the visual field
- Information about both the sensitivity and its response delay is obtained at every visual field region
- Each visual field parameter comes with measurement error, this allows things like the CPSD to be calculated with no extra test time
- Relative pupil size is used so senescent pupils are not a problem
- Blinks and fixation losses are automatically monitored and data from these are rejected
- When the pupil size is large the upper portion of the pupil is not tracked to minimize the effects of ptosis
- The stimuli are blurred so that they are quite tolerant of mis-refraction, up to 3D spherical equivalent
- The stimuli are yellow to minimize the effects of differ levels of brunescence of the lenses of the subjects, and also blue-blocking IOLs. Longer wavelength stimuli may reduce scattering due to media opacities somewhat also.