Simultaneous multifocal pupillographic visual field assessment of both eyes

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1. Purpose: To investigate the diagnostic power and repeatability of 8 variants of multifocal pupillographic perimetry in open angle glaucoma using a prototype of the TrueField Perimeter, Fig 1.
2. Design: Experimental design.
3. Participants: Eight stimulus protocols were examined in two blocks of experiments. Block 1 contained 40 normal and 39 glaucoma subjects; block two: 42 normal and 61 glaucoma subjects. Diagnosis was confirmed by examining all subjects with HFA achromatic, and Matrix 24-2 perimetry, Stratus OCT, slit. All subjects gave informed written consent.
4. Methods: Independent multifocal stimuli were presented concurrently to both eyes, having 44 independent test regions/eye extending to 30 deg eccentricity, Fig 2. The recording duration for 5 protocols was 4 min., divided into 8 segments of 30 s each, and for the other 3 was 6 min. divided into 9 segments of 40 s. Stimuli in each protocol could differ in the presentation rate per stimulus region (0.25, 1, presentations/s), or luminosity (150, 180, 290 or 340 cd/m²). Background luminance was 10 cd/m². Since both pupils responded to stimuli from both eyes, 88 responses/eye were obtained giving 176 contraction amplitudes and 176 delays per protocol, with SE for all 352 measures. Retest was done within 4 weeks. Visual fields were classified by HFA mean defects: moderate: 6 to 12 dB, severe: >12 dB.
5. Main outcome measures: The relative diagnostic power of the 8 protocols was examined using areas under receiver operator plots (AUC). The signal qualities were quantified as the median t-static across regions and subjects for peak (relative) constriction amplitude.
6. Results: In Block 1 for severe fields the mean of the 20 regional amplitudes that most deviated from the normative data gave an AUC of 0.98 ± 0.01 (mean ± SE, Table 2). The median t-stat for that protocol was 2.79 ± 0.29 (Table 1). In Block 2 a 6 min. version of the best protocol of Block 1, P122, had a median t-stat of 3.08 ± 0.33, with a concomitant improvement in test-test variability.
7. Conclusions
This study indicates that multifocal pupil perimetry can yield acceptable diagnostic power, excellent median signal quality and test-retest variability comparable to the Matrix perimeter using a test duration equivalent to 3 min/eye. Data on efferent and afferent defects is obtained for all regions and data from blinks and fixation losses are automatically discarded.

Figure 1. TrueField Analyzer which can be seen at the Technical Exhibition

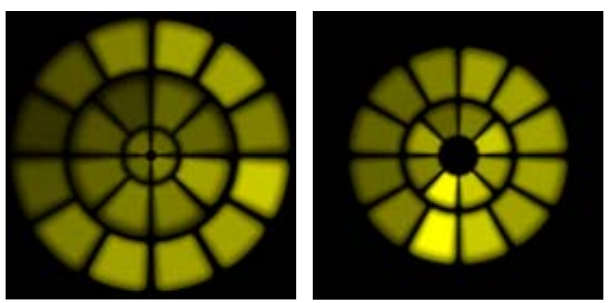

Figure 2. Example of the luminance balanced stimuli used here . The stimuli illustrated are the 44 that would be resented to the left eye, the right eye stimuli were left-right mirror symmetric.

	Stimulus Protocol	Mean Presentation Interval (s)	Max Luminance	Duration (Min)	Median t-stat normal	Median t-stat glaucoma
Block 1	P117	1	290	4	2.64	2.32
	P118	1	340	4	2.86	2.40
	P119	1	340	4	2.60	2.25
	P120	4	150	4	2.98	2.43
Block 2	P121 =120	4	150	4	2.55	2.32
	P122	4	150	6	3.08	2.7
	P123	4	150	6	1.96	1.63
	P124	4	180	6	2.07	1.71

Table 1. Stimulus definitions and median per region t-stats. Columns 3 to 5 give the the differences between the 8 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
Block 1	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
Block 2	Moderate	37	68.6 ± 5.0	70.3 ± 4.8	67.4 ± 4.1	77.2 ± 4.4
	Mod + Sev	58	76.8 ± 3.6	79.6 ± 3.5	79.2 ± 3.0	81.6 ± 3.2
	Severe	21	92.5 ± 2.1	97.7 ±2.0	96.2 ± 2.0	87.6 ± 3.0

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 fields HFA MD 0 to -6 dB, moderate MD -6 to -12 dB, severe fields MD worse than -12 dB. Each eye was tested twice so the number of fields in the ROC analysis is twice the number of eyes.

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

- The non-contact and objective test is about twice as fast as current perimeters
- The visual fields of both eyes are measured concurrently and both the sensitivity and delay are obtained for all field regions
- 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
- 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
- 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. The stimuli probably activiate the cone mediated Yellow-on/Blue-Off pathway and so have some relationship to SWAP stimuli