The Java Open Visual Psychophysics (JOVP)

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There is no conflict of interest

Purpose:
As mobile devices are making their way into vision research and ophthalmology and optometry practice, the demand of visual psychophysics software that can be ported to a wide range of modern architectures is growing. The Java Open Visual Psychophysics (JOVP) engine is an effort to enable the development of applications for visual psychophysics that can be easily ported from desktop PCs to mobile devices and microdisplays embedded on commercial and experimental ophthalmic devices such as aberrometers, adaptive-optics visual simulators, and micro-perimeters. Currently, it is on the early stages of development.

Methods:
JOVP is an engine built on top of Vulkan, a cross-platform application programming interface for 3D graphics and computing. Vulkan is the successor of OpenGL and offers higher performance and more efficient usage of graphical hardware. As the goals of JOVP are to streamline development and reduce the implementation effort required to bring new ideas from conceptualization to application prototyping. For instance, it has presets for common psychophysical paradigms that can later be customized as software matures. It also contains Sloan optotypes as well mathematical models for conventional and customizable visual patterns (e.g., Gabor patches).

Results:
The JOVP creates a virtual world from the perspective of an observer looking at a display at a given (optical) distance. Thus, fixation targets, stimuli, distractors, etc., are specified in degrees of visual angle and cycles per degree. The JOVP engine queries the hardware for technical details, such as pixel density, color depth, and physical size. This technical information is then used to render visual items during runtime ensuring that distances within the virtual world do not change from one device another (e.g., from a PC screen to a head-mounted display).

Conclusions:
The key differences that distinguish JOVP from other, well stablished toolboxes (with the psychtoolbox as the prime example) are its emphasis in the development of highly portable applications and that it works without the need for expensive commercial software or additional hardware. Future plans include the development of modules for eye tracking, 3D vision and color perception. Other features such as stimulus modulation to account for image distortion and magnification generated by additional lenses included in the observer's optical path (e.g., trial lenses to correct for astigmatism) are also underway.

Using artificial responses to speed up perimetric tests

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Purpose: To investigate the utility of a method (ARBON) for injecting artificial responses into a perimetric procedure based on the neighbours of a tested location.

Methods: During a test, ARBON keeps track of all possible threshold values that could eventuate at each location in the visual field. When a presentation is about to happen at a location, ARBON checks if the thresholds that could eventuate from a 'yes' response are disjoint from those that could eventuate if a 'no' response is given at that location and whether either of these ranges of possible thresholds are a subset of the ranges of possible thresholds of the direct neighbours of the location. If both these conditions hold, then the corresponding 'yes' or 'no' response is automatically given and the next stimulus value for the location is considered.

To test the utility of this approach, we apply it to a ZEST procedure that mimics typical current clinical perimetric algorithms. The ZEST uses a bimodal prior, steep likelihood that is that same for all locations, and terminates when the standard deviation of the probability distribution drops below 2.0 dB. We compare the baseline ZEST with a Truncated version using a standard deviation of 2.5 dB (as an alternate means of reducing test time) and the baseline with the ARBON logic added.

We simulate the three algorithms using the *SimHenson* model of the Open Perimetry Interface [1] on 610 normal 24-2 fields (ages 20 to 80) and 163 glaucomatous 24-2 fields (median MD -1.8 dB, 95th percentile -22.6 dB) measuring number of presentations for the whole field and mean absolute error of threshold estimation over 1000 repeats of each field. We assumed a false positive rate of 10% and false negative rate of 3% in the simulations. In addition to speed and accuracy of individual fields, we look at the overlap coefficient of the distribution of measured thresholds between the methods.

Results: Results for whole field speed and accuracy are shown in Table 1. Adding ARBON to the baseline reduces the number of presentations by 16% and 12% on normal and glaucomas respectively, whereas reparametrising the baseline to get Truncated reduces presentations by 20% and 18%. However, Truncated increases the mean absolute error by 8% in both cases, while adding ARBON improves normals by 7% and leaves glaucomas unchanged. The distribution of measured thresholds using Truncated overlapped 48% with the baseline for normals and 84% for baseline+ARBON.

Conclusions: Adding ARBON to a procedure does not require any change to the underlying procedure and reduces the number of presentations while maintaining accuracy. Further, the distribution of measured thresholds remains similar to the underlying procedure.

Table 1: Results of simulations.

		Number of Presentations		Absolute Error		Error	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Normals	**Baseline**	191	61	1.61	1.39	0.42	2.08
	Truncated	154	60	1.74	1.52	0.37	2.28
	Baseline+ARBON	161	67	1.50	1.29	0.15	1.97
Glaucoma	**Baseline**	225	98	2.30	2.77	0.97	3.46
	Truncated	184	92	2.48	2.89	0.92	3.70
	Baseline+ARBON	198	104	2.29	2.63	0.77	3.40

Conflict of Interest: Both Authors (F) Haag-Streit AG, CREWT Medical Inc. (C) CentreVue SpA

Invariance of test-retest variability with spot stimulus configuration

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Purpose: To compare test-retest (TRT) characteristics of perimetric stimuli due to stimulus configuration alone.

Methods: Fifteen patients with glaucoma (median [IQR] age: 69.5 [67.5, 72.1] years) and five age-similar healthy controls (median [IQR] age: 71.9 [67.6, 72.5] years) were followed over 5 visits within 11 weeks with measures of threshold for 3 different stimulus forms, each designed to tap into changes in spatial summation in glaucoma, as well as a Goldmann III-equivalent (reference) stimulus. One stimulus modulated in area (A; fixed contrast: log $\Delta I/I$: −0.30), another in contrast within Ricco's area (C_R; area: -1.93 log deg^2), and another in both area and contrast simultaneously (AC). The GIII-equivalent stimulus modulated in contrast (GIII; area: -0.95 log deg^2). Presentation duration was 200ms for all stimuli. Stimulus steps were converted to energy units (luminance × area × duration). Test parameters unrelated to stimulus configuration and other external confounders (e.g. scale, energy step size, test platform) were equalized or minimized, to isolate the effect of stimulus configuration alone. Thresholds were measured at 18 locations with an adaptive 1-up/1-down staircase on a γ-corrected OLED display (Sony PVM-A250). The area between the 5th-95th percentiles of TRT variability (area between limits, ABL) was compared between stimuli.

Results: TRT variability was positively associated with threshold for all stimuli, i.e. greater TRT variability was found in regions of higher threshold (lower sensitivity). Differences in TRT variability between stimuli (even between large and small stimuli where an effect is often reported), within overlapping dynamic ranges, were negligible (ABL: A=0.80, AC=0.89, C_R=0.79, GIII=0.79).

Conclusions: TRT variability is largely invariant of stimulus configuration when non-configuration factors, such as energy step size, are equated. Given previously demonstrated uniformity of intra-test variability with defect depth and higher SNR with area-modulated stimuli [Rountree et al, Sci Rep, 2018;8:2172], increasing TRT variability with defect depth may be more indicative of neural noise in glaucoma than variability due to the stimulus. The choice of stimulus for clinical adaptation should be informed by SNR rather than TRT variability alone and should not be biased by non-configuration-related factors. Caution should be exercised when attributing differences in TRT variability, in packaged tests, to stimulus configurations.

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Suprathreshold approaches to spatially mapping the visual field in advanced glaucoma

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Purpose

Current perimetric threshold measurement techniques are unreliable and time-consuming in advanced loss. An alternative approach may be to measure spatial extent of residual visual field. Here, we test two suprathreshold approaches to mapping the visual field that we hypothesised to be faster, more accurate and more precise than existing procedures in advanced glaucoma.

Methods

Empirical data from 97 patients with Mean Deviation worse than -10dB were used as input to computer simulations comparing two suprathreshold procedures run on a high-density grid (1.5°, central 27°) to interpolated 24-2 Full Threshold (FT). Spatial Binary Search (SpaBS) presented at locations bisecting seen/unseen points in any direction until all neighbours' seen status matched or tested points were adjacent. SupraThreshold Adaptive Mapping Procedure (STAMP) presented stimuli at locations with maximum entropy and modified the status of all local points after each presentation, stopping after a fixed number of presentations. Both new procedures presented stimuli only at 20dB. Accuracy was defined as the percentage of locations whose seen status matched that of the interpolated input data classified as seen/unseen at 20dB. Repeatability was defined as abs(2 x proportion seen over repeat tests -1), such that 1 represented perfect repeatability and 0 represented chance.

Results

For typical response errors, FT used median 310 (interquartile range [IQR] 274-335) presentations vs. 284 (IQR 259- 309) for SpaBS, but SpaBS had worse mean accuracy and repeatability than FT (both $p<0.0001$). Compared to FT, mean accuracy (FT: median 91%, IQR 87-94%) was slightly better with STAMP for stopping criteria ≥50% of conventional test duration (accounting for reduced presentations by SITA Std vs FT), though this was only statistically significant at 100%, and mean repeatability was similar for all stopping criteria ($p\geq0.02$) compared to FT (median 91%, IQR 87-94%). Findings were robust to changes in response error frequencies.

Conclusions

STAMP accurately and repeatably maps the spatial extent of advanced visual field defects within 50-70% of conventional test duration against a benchmark of a conventional test with post-hoc spatial interpolation. Further work is necessary to refine STAMP, and to establish the extent of benefits to patient comfort of the suprathreshold approach.

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Conflict of Interest

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Increasing spatial sampling in perimetry: a case series exploration of clinician preferences relative to automatic placement of stimuli in areas of steep visual field gradient

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Purpose:

The Australian Reduced Range Extended Spatial Test (ARREST) is a new perimetric approach that adds test locations to the visual field in subsequent tests while keeping presentation count similar to current clinical procedures. ARREST chooses the steepest gradient in the visual field for new locations independent of disease type or structural information. This study asked clinicians to choose new stimulus locations for a case series of visual fields with established glaucomatous visual field loss, with and without OCT information and compared those choices to ARREST.

Methods:

This study was conducted online using a custom-developed R Shiny web application. The web app comprised 24-2 visual fields and the OCT cp-RNFL thickness profile of twelve cases with glaucoma. On the first page, a 24-2 visual field on a clickable 2-degree spaced test grid was displayed, and the clinicians were asked to choose a prescribed number of new test locations based on the 24-2 visual fields. Subsequently, the second page showed the corresponding cp-RNFL thickness map of the same case along with the 24-2 visual field and the clinicians were again instructed to select their preferred test locations. The specific locations chosen by ARREST for these same patient cases were derived previously (Muthusamy et al, TVST. 2020: 9(13):24) and used for comparison.

Results:

Eighteen ophthalmologists and optometrists with expertise in glaucoma participated. The proportion of overlap between newly added locations was analysed using a measure of spatial overlap ranging from 0 indicating no overlap and 1 perfect overlap. The median spatial overlap between the clinicians, when provided only 24-2 visual field was 0.28 (IQR: 0.17, 0.42), and both the 24-2 visual field and the cp-RNFL thickness profile was 0.27 (IQR: 0.14, 0.40). These did not differ (Wilcoxon signed-rank test, $p = 0.15$). Most clinicians did not change their location placement choice when provided with the additional cp-RNFL profile (within-clinician overlap: 0.7 (IQR: 0.51, 0.91)). The pooled median spatial overlap of locations chosen by visual field gradient alone (ARREST approach) and each clinicians' choice for stimulus placement was 0.31 (IQR: 0.20, 0.41) with 4, 10, and 12 clinicians choosing at least one location within 2, 4, and 6 degrees of the ARREST chosen locations.

Conclusions:

Clinicians vary in selecting new stimulus locations and tend not to change their location placement when provided with the additional cp-RNFL thickness map in cases with established glaucoma. Selecting visual field locations based on gradient alone results in a similar level of overlap with clinician choice, as does clinicians amongst themselves.

Conflict of Interest details

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