Development of an age-corrected normative database for saccadic vector optokinetic perimetry (SVOP)

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**PRECIS**

Normal age-corrected threshold sensitivity values were determined for a new eye tracking perimeter and compared to standard automated perimetry.

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ABSTRACT

**Purpose:** To determine threshold visual field sensitivities in normal subjects performing saccadic vector optokinetic perimetry (SVOP), a new eye tracking perimeter.

**Patients and Methods:** 113 healthy participants performed SVOP and standard automated perimetry (SAP) in both eyes with the order of testing randomized. The relationship between SAP and SVOP sensitivity was examined using Bland-Altman plots and 95% limits of agreement. The relationship between sensitivity and age was examined by pointwise linear regression and age-corrected normal threshold sensitivities were calculated.

**Results:** After excluding unreliable tests, 97 participants with a mean age of 65.9 ± 10.1 years were included. Average SAP mean deviation (MD) was -0.87 ± 1.56 dB, SAP sensitivity was 29.20 ± 1.68 dB and SVOP sensitivity was 32.18 ± 1.96 dB. SVOP had a longer test duration (431 ± 110 compared to 307 ± 42 seconds for SAP, P<0.001). On average, the mean sensitivity obtained using SVOP was 2.98 dB higher than average SAP sensitivity, with 95% limits of agreement of -0.11 to 6.15 dB. For each decade older, SAP sensitivity decreased by 0.93 dB (95% CI 1.21 to 0.64) and SVOP sensitivity decreased by 1.15 dB (95% CI 1.47 to 0.84).

**Conclusions:** The results provide age-corrected normative values for threshold sensitivities from SVOP. Overall, SVOP provided a similar shaped hill of vision as SAP however threshold sensitivities were higher, meaning results are not interchangeable.

**Keywords:** Perimetry, Glaucoma, Visual Fields, Eye tracking
Perimetry is routinely used to screen for abnormalities of visual function caused by diseases such as glaucoma, with standard automated perimetry (SAP) the prevailing modality. SAP uses a white static stimulus displayed against a white background, with the contrast of the stimulus varied according to a staircase strategy to determine differential light sensitivity (DLS).\textsuperscript{1,2} SAP has become the ‘gold standard’ perimetric test, yet patients often find it difficult to perform.\textsuperscript{3} Though patients accept that visual field testing is important, they find it more demanding than other common clinical tests and a qualitative investigation discovered a perception among patients that multiple visual field tests were needed to become comfortable and to gain an accurate representation of their vision.\textsuperscript{3,4} A further problem is that SAP is subject to considerable test-retest variability with the result that patients may need repeat testing to establish a diagnosis and to confidently identify change over time.\textsuperscript{5}

In 1989 Johnston and colleagues described a method of computerized perimetry using a moving fixation target.\textsuperscript{6,7} Throughout testing patients were required to use a mouse to hold a circle-shaped cursor over a moving fixation target. Stimuli were only presented when the cursor was held in the correct position and the patient was instructed to press a response button when the stimulus was seen. A similar approach is used by the Melbourne Rapid Fields (MRF) visual field test, an FDA cleared application, to enable testing of 30 degrees of visual field using a tablet computer with a screen size of only 9.7 inches.\textsuperscript{8} The MRF also relies on the patient touching the screen, clicking a mouse, or pressing a key to register responses to stimuli. Eye trackers have long been used to monitor fixation during perimetry, however, several groups have recently developed software for eye-tracking based perimetry.\textsuperscript{9-12} For example, Jones and colleagues used a 50 Hz eye tracker mounted on a tablet computer using magnets to test visual field using fixed luminance stimuli across 20 degrees of visual field.\textsuperscript{12} In a feasibility study, there was strong correlation between SAP
mean deviation and measurements obtained from the eye-tracking perimeter, and eye-tracking perimetry had good ability to differentiate patients with glaucoma from controls.

We have recently described a new method of automated threshold visual field assessment, known as Saccadic Vector Optokinetic Perimetry (SVOP).\textsuperscript{13-17} SVOP uses eye tracking to quantify natural eye movements that occur in response to stimuli presented using a computerized screen. SVOP was initially developed for use in children and so was designed to not require a chin rest or need the patient to press a response button.\textsuperscript{13} The software uses the preceding stimulus as the fixation spot for the next stimulus and automatically adjusts the size and position of the stimulus allowing the patient to move their head freely during testing. A stimulus is registered as seen if there is a saccadic eye movement towards the stimulus within a prespecified time from first presentation. SVOP therefore potentially provides a more intuitive experience for patients, which is likely to be particularly beneficial for those that struggle to maintain fixation or have difficulty holding and pressing a button to register a response.

We have previously shown good correlation between threshold sensitivity values obtained with SVOP and SAP in patients with glaucoma and demonstrated SVOP to have high repeatability.\textsuperscript{16,17} Most patients found SVOP comfortable, with 71\% of patients preferring SVOP compared to SAP.\textsuperscript{17} The aim of this study was to examine threshold sensitivity values of healthy individuals using SVOP and to compare results to SAP. These values could then be used to develop a normative database of differential light sensitivity values for the SVOP device.

PATIENTS AND METHODS

Healthy participants were recruited through the Scottish Health Research Register (SHARE), a database of over 206,000 people interested in participating in medical research.\textsuperscript{18}
All participants were provided written informed consent prior to enrolment and all study methods were prospectively approved by the South-East Scotland Research Ethics Committee (Reference 13/SS/0045). The study adhered to the tenets of the Declaration of Helsinki.

Participants underwent a baseline optometric examination, including best-corrected visual acuity and focimetry of the current spectacles. Healthy participants were required to have no previous history of significant eye disease, no known history of visual field defect and no neurological conditions that might affect the visual field. All participants were required to have a best corrected visual acuity of 20/30 or better in each eye. Participants with refractive error of greater than ± 7D spherical equivalent or more than 3D cylinder were excluded.

All participants completed SAP and SVOP in both eyes with the order of testing randomized. SAP was performed using a Humphrey Field Analyzer (HFA) 750i (Carl Zeiss Meditec, Dublin, CA) using the 24-2 test pattern and SITA Fast algorithm. SVOP was performed at the same visit using a research device, which has previously been described in detail.\(^\text{16,17}\) Visual field tests were reviewed for reliability. SAP tests with ≥15% false positives or ≥20% fixation losses were considered unreliable and excluded. SVOP does not provide information about false positives or fixation losses as it inherently accounts for fixation by only presenting stimuli once fixation is achieved for each test location. SAP and SVOP tests were reviewed for artefact, e.g. lid artefact, and were excluded if artefact was present. Participants found to have a visual field defect confirmed by repeat testing were excluded as the study was focused on normal individuals.

**Saccadic Vector Optokinetic Perimetry (SVOP)**

The threshold SVOP device consists of a personal computer with a 24” high-resolution LCD screen (Eizo ColorEdge CG243W, Hakusan, Japan) and an eye tracker (X2-
60 model, Tobii Technology, Stockholm, Sweden) (Figure 1). The eye tracker assesses gaze responses to stimuli presented on the display screen. A stimulus is registered as seen if there is a saccadic eye movement towards the stimulus within a prespecified time from first presentation. The eye tracker also provides ‘real time’ data on eye location meaning that the size and position of the stimuli can be automatically and continually adjusted to compensate for changes in the patient’s position during testing.

During testing, participants were seated in front of the LCD screen with their eyes aligned with the screen’s center at an initial distance of 55 cm. Each eye was tested separately using custom made test spectacles, which occluded the non-test eye with an infrared bandpass filter. A best vision sphere lens was then placed in front of the test eye, the power of which was calculated based on focimetry readings taken from the subjects’ own glasses and adjusted for the (55 cm) working distance of the test where necessary. The infrared bandpass filter enabled the eye tracker to detect the position of the occluded eye to monitor the position of the patient. The test began with a 20 second demonstration which was followed by a calibration sequence. During testing the patient was instructed to follow their natural reaction to fixate towards any stimulus perceived. The eye tracker evaluated responses to the stimuli and software determined whether the stimulus had been seen based on the direction and amplitude of the gaze response. Whether or not the stimulus was seen was determined based on the direction and amplitude of the change in eye position relative to the stimulus and the point of fixation (preceding stimulus). The start of a fixation change was defined as the start point of a >50 pixels change in gaze and the end location of a fixation change was defined by the point at which 5 consecutive gaze data samples were separated by a distance of <50 pixels, occurring after the detection of a fixation change start point. Stimuli were equivalent to Goldmann size III and each stimulus was presented for 200 ms using coordinates equivalent to the SAP 24-2 test pattern. A duration of 200 ms was selected
as it is the same duration used by the HFA and previous work has shown visual processing speed and speed of the saccade response is sufficiently fast to reach a stimulus within this time period.\textsuperscript{19,20} Saccades larger than 5 degrees take only approximately 20 to 30 ms, with an additional 2 ms for each additional degree.\textsuperscript{19}

As SVOP uses a flat LCD screen rather than a projection system, the way in which stimuli of different luminance are displayed is inherently different to SAP. In an LCD screen, light is provided by a fluorescent backlight, which passes through layers of polarizing material, attenuating and filtering light to produce different colors. Different colors have different luminance as more or less backlight is allowed to pass and therefore different colors can be used to produce different levels of luminance. Grey-scale level colors were produced by setting red, green and blue (RGB) levels to equal each other and luminance varied by adjusting levels. RGB levels range between 0 and 255, therefore the maximum level of luminance was obtained by setting the RGB level to 255, 255, 255 and the minimum to 0, 0, 0. Screen calibration was performed using a Look-Up Table to pair grey-levels of each pixel to the corresponding required background (10 Cd/m\textsuperscript{2}) and stimulus luminance levels.

LCD screens may show variability in luminance across the screen. To minimize the risk of variability in luminance affecting results, uniformity of the display screen was assessed using a luminance meter (L203 photometer, Macam Photometrics Ltd, Livingston, UK). Luminance values were examined for different grey-scale levels to ensure LCD RGB values corresponded to stimulus luminance used by SAP. For example, a stimulus of 20 dB (41.9 Cd/m\textsuperscript{2}) was found to be equivalent to an LCD RGB value of 136, 136, 136. Stimuli luminance replicated the luminance values corresponding to 14 to 40 dB with SAP, with the background to stimuli luminance ratio also replicated. The LCD display was unable to display stimuli with luminance <14 dB due to the maximum intensity being limited by the maximum luminance of the LCD backlight.
Thresholds were obtained using a 4-2 bracketing strategy and began by testing four ‘seed’ locations (one in each quadrant), which were then used to set the starting stimulus luminance levels for neighboring locations which in-turn were used to calculate the remaining starting luminance levels. The SVOP stimulus intensity and background intensity values were matched in luminance to those of SAP to allow direct comparison.

**Statistical Analysis**

Testing was performed for both eyes however the primary analysis was conducted on right eyes only. As differential light sensitivity is measured using logarithmic units, all sensitivity values were transformed to linear values to calculate average SAP and SVOP sensitivities for each eye. The relationship between SAP and SVOP visual field sensitivity was examined using scatter plots and pointwise linear regression. Bland-Altman plots were used to compare results from SAP and SVOP and determine 95% limits of agreement.

Normality was tested by inspection of histograms and by Shapiro-Wilk test. Parametric variables were compared using student t-test and non-parametric variables compared using Wilcoxon rank sum test. The relationship between sensitivity values and age was examined by pointwise linear regression analysis and expected sensitivity values were estimated for each test point for a 50 year old individual. All statistical analyses were performed with commercially available software (STATA version 14; StataCorp LP, College Station, TX). The α level (type I error) was set at 0.05.

**RESULTS**

Both eyes of 113 healthy participants were tested. Of the 113 SAP tests of right eyes, 16 were excluded due to artefact or due to having ≥ 15% false positives or ≥ 20% fixation losses, leaving 97 for analysis. No SVOP tests needed to be excluded. The average age of included participants was 65.9 ±10.1 years and 59 of 97 (60.8%) were female. Demographic
and clinical details of participants are shown in Table 1. Included eyes had an average SAP MD of \(-0.87 \pm 1.56 \) dB, average SAP sensitivity of \(29.20 \pm 1.68 \) dB and average SVOP sensitivity of \(32.18 \pm 1.96 \) dB. Average sensitivities were significantly higher using SVOP compared to SAP (\(P<0.001\)). Average test duration was significantly longer for SVOP compared to SAP (\(431 \pm 110 \) seconds for SVOP compared to \(307 \pm 42 \) seconds for SAP, \(P<0.001\)) (Table 1).

Figure 2 shows a Bland Altman plot showing the relationship between paired differences and their average SVOP and averages SAP sensitivities. On average, the mean sensitivity obtained using SVOP was \(2.98 \) dB higher than average SAP sensitivity, with 95% limits of agreement of \(-0.11 \) to \(6.15 \) dB. Regression analysis indicated that for each decade older, SAP sensitivity decreased by \(0.93 \) dB (95% CI 1.21 to 0.64, \(P<0.001\), \(R^2 = 0.311\)) and SVOP sensitivity decreased by \(1.15 \) dB (95% CI 1.47 to 0.84, \(P<0.001\), \(R^2 =0.357\)). The relationship between age and average SAP and SVOP sensitivity is shown in Figures 3A and 3B. The relationship between age and visual field sensitivity for each test point of SVOP and SAP derived from linear regression is shown in Figures 4 and 5 with the estimated normal sensitivity values for a 50-year-old healthy subject also shown.

Figure 6 shows the difference in estimated difference in normal sensitivity values between SVOP and SAP for a 50-year-old subject. Similar results were seen for left eyes, with average sensitivity from SVOP on average \(3.16 \) dB greater than average sensitivity from SAP, with 95% limits of agreement of \(0.50 \) to \(5.82 \) dB. Results of further analyses for left eyes is shown in the supplemental digital content.

Regression analysis of data from left eyes indicated that for each decade older, SAP sensitivity decreased by \(1.03 \) dB (95% CI 1.39 to 0.66, \(P<0.001\), \(R^2 = 0.284\)) and SVOP
sensitivity decreased by 1.09 dB (95% CI 1.46 to 0.73, P<0.001, R² =0.316), which was similar to the relationship observed in the primary analysis for right eyes.

Agreement between SAP and SVOP was also evaluated for the 40 participants randomized to SAP first and compared to the 57 randomized to SVOP first. For those tested with SAP first, the mean difference in average sensitivity was 2.89 dB (95% CI 2.32 to 3.45 dB), with 95% limits of agreement of -0.54 to 6.32 dB. For participants tested with SVOP first, the mean difference in average sensitivity was 3.12 dB (95% CI 2.71 to 3.52), with 95% limits of agreement of 0.08 to 6.15 dB.

The shapes of the predicted hills of vision for a 50-year-old subject obtained by SVOP and SAP were also compared graphically using a three-dimensional surface plot (Figure 7). There was a significant relationship between threshold sensitivity and eccentricity of visual field test point on SVOP (coefficient = -0.19, 95% CI -0.21 to -0.17, P<0.001, R² = 0.077), though the relationship was stronger for SAP (coefficient = -0.29, 95% CI -0.31 to -0.27, P<0.001, R² = 0.183) (Figure 8). Similar results were found for left eyes, shown in detail in the supplemental digital content 1, http://links.lww.com/IJG/A448.

DISCUSSION

The results of this study provide age-corrected normative values for threshold sensitivities using SVOP, a new eye tracking perimeter. Overall, SVOP provided a similar shape ‘hill of vision’ for normal subjects as SAP using the SITA Fast strategy (Figure 7), however, thresholds with SVOP were on average higher than with SAP. The overall average threshold sensitivity with SVOP was 32.18 ± 1.96 dB compared to 29.20 ± 1.68 dB with SAP. Mean sensitivity from SVOP was therefore, on average, almost 3 dB higher than from SAP, with relatively wide 95% limits of agreement of -0.11 to 6.15 dB. These findings indicate that SVOP and SAP cannot be used interchangeably.
A possible reason for the higher threshold detected with SVOP is the longer test duration, which may have caused participants to become fatigued. However, we have previously found patients prefer SVOP compared to SAP despite the longer test duration.¹⁷ This is likely due to the lack of a need to maintain position throughout the test or for the patient to place their chin on a rest. Another possible reason for the higher thresholds with SVOP is lack of precision, however this is unlikely to be the case as SVOP has previously been shown to have good repeatability.¹⁴ It is also possible that differences were due to calibration of the LCD screen, and though we tested luminance across the screen using a photometer prior to enrolling the first participant, this was not retested during the study.

Several previous studies have examined normal threshold values for perimetry using various SAP testing strategies, with many showing differences in thresholds between tests.¹²,²¹-²³ Bengtsson and colleagues found average age-corrected normal sensitivity was higher for SITA Standard and SITA Fast compared to Full Threshold, with mean sensitivities of 29.5 dB, 29.9 dB and 28.3 dB respectively.² The differences between strategies were largest in the more peripheral test points. It was concluded that the normal hill of vision was likely to be somewhat higher and smoother with SITA Fast and SITA Standard compared to Full Threshold testing. We found, differences between SVOP and SAP using SITA Fast were similar across test points which led to similar shaped hills of vision (Figure 7).

Differential light sensitivity is known to decrease with age. We found a similar relationship between age and threshold sensitivity using SVOP and SAP, though the rate of age-related decline was slightly faster with SVOP. On average, SAP sensitivity decreased by 0.93 dB per decade (95% CI 1.21 to 0.64). Bengtsson and colleagues found an age-related reduction of 0.62 dB per year with SITA Fast, however their study used the 30-2 rather than 24-2 test pattern used in the present study.² We found SVOP sensitivity decreased by 1.15 dB per decade (95% CI 1.47 to 0.84). Bengtsson and colleagues also observed differences in age-
related decreases in differential light sensitivity between testing strategies with 25% and 23% smaller changes compared to Full Threshold testing for SITA Fast and SITA Standard respectively.² Bengtsson reported age-related reductions in sensitivity of 0.083 dB per year with Full Threshold and 0.064 dB per year with SITA Standard.

Heijl and colleagues have previously reported steeper age-related declines in visual field sensitivity in more peripheral test points, when using a Full Threshold test.¹ Point wise age-related slopes ranged from 0.36 to 1.18 dB per decade leading to a depression and steepening of the normal hill of vision with age. Our analysis of SAP tests found point wise age-related slopes of 0.05 to 0.28 dB per decade (Figure 5). Though we found slower predicted age-related decline in sensitivity than Heijl, likely due to use of the SITA Fast 24-2 rather than 30-2 Full Threshold strategies, there was agreement in finding faster rates of age-related loss in midperipheral compared to paracentral test locations, leading to depression and steepening of the hill of vision. The relationship between age and visual field sensitivity was similar for SVOP (Figure 4), with similar point-wise age-related slopes ranging from 0.07 to 0.22 dB per decade. The predicted rates of age-related decline were however, more similar across the visual field. For example, Figure 4 shows paracentral SVOP test points had rates of change (coefficients) of between 0.14 and 0.22 dB per decade, whereas peripheral test points ranged between 0.07 and 0.21 dB per decade. Therefore, the age-related decline in SVOP sensitivities appears to be more uniform, with a depression in the hill of vision, similar to that observed with SAP, but without the steepening.

SVOP has potential advantages over conventional automated perimetry, including the lack of the need for the patient to concentrate on maintaining fixation on a single point, and the lack of a need to press a response button. And it is perhaps for these reasons that SVOP seems to be preferred by patients.¹⁷ SVOP also provides information on characteristics of saccades such as accuracy and latency, which have been shown to be impaired in glaucoma.²⁴
Though not directly examined in the present study, it would be interesting to examine whether characteristics of saccades may be of additional diagnostic value to differential light sensitivity alone. The present study has however highlighted potential disadvantages of SVOP compared to SAP, including the significantly longer test time, with SVOP on average taking over 7 minutes compared to only 5 minutes for SITA Fast. At present SVOP uses a full threshold algorithm so it is likely test time could be reduced with further modifications to the algorithm.

It is also important to emphasize limitations of the study, including the relatively small number of participants, and that testing was conducted using a single SVOP device at a single site. In addition, patients performed only one SAP and SVOP test in each eye meaning that we were not able to assess variability in thresholds in this particular group. Variability in visual fields is likely to be greater in those without previous experience, which may affect the accuracy of test results. Previous studies assessing normal threshold sensitivity values have tended to include results from second or third tests.\(^2\) We did however test right and left eyes and found similar results from both eyes, with no sign of learning effect affecting results. A further potential limitation is the choice of SITA Fast tests as the reference standard. SITA Fast was selected as this is the test used in routine practice in our department, however it is important to appreciate that threshold sensitivity values tend to be higher with shorter test, perhaps as visual fatigue tends to decrease threshold values with increasing test time.\(^25\) A comparison between SITA Standard and SVOP would have likely shown a smaller difference in test time and threshold sensitivity values. It is also important to emphasize that in some circumstances eye tracking may be problematic, for example in patients with nystagmus, ptosis, or corneal or pupil abnormalities, including anisocoria and abnormal pupil shape, eye trackers may not function correctly. In preliminary work developing SVOP we also noted a failure of eye tracking in a patient with a large iridectomy. In this case the tracker jumped
between the pupil and iridectomy and the test could not be completed. A further limitation is that we did not examine missing or invalid eye movement data, which may have been useful a measure of gaze tracking reliability. This data is not currently provided as an SVOP output measure, but it may be useful to develop as an additional reliability index for SVOP testing.

Despite limitations, eye-tracking perimetry is an attractive proposition which overcomes some of the disadvantages of SAP. Several groups have developed devices for eye-tracking perimetry proving feasibility and widely reporting that it is preferred by patients to SAP.7-12,16 17 Eye tracking perimeters have also shown good ability to determine threshold visual field sensitivity and produce maps of visual field defects with patterns exhibiting close agreement to SAP.17 However, to the best of our knowledge, no attempt has been made to generate a normative database for an eye-tracking perimetry device. The present study provides age-corrected normative data for the threshold SVOP test, which may be useful in determining cut off values for detection of abnormality. The normative values could be used to generate age-corrected deviation maps, similar to those generated by other automated perimeters.
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Figure Legends

**Figure 1.** Photograph of the SVOP device.

**Figure 2.** Bland Altman plot showing relationship between paired differences and their average for average SVOP and average SAP sensitivities for healthy participants.

**Figure 3.** Scatter plots showing the relationship between average SAP sensitivity and age (A) and average SVOP sensitivity and age (B).

**Figure 4.** Constants, coefficients and R-squared values from linear regression of sensitivity and age for individual test points of the SVOP test (A). Expected normal sensitivity values for individual test points of the SVOP test for a 50-year-old healthy subject (B).

**Figure 5.** Constants, coefficients and R-squared values from linear regression of sensitivity and age for individual test points of the SAP test (A). Expected normal sensitivity values for individual test points of the SAP test for a 50-year-old healthy subject (B).

**Figure 6.** Estimated difference between expected normal sensitivities (in decibels) obtained from SVOP and SAP (SVOP minus SAP) for a 50-year-old.

**Figure 7.** Predicted hill of vision for SVOP and SAP for a 50-year-old. Results shown for SVOP (A) and SAP (B) including the blind spot and for SVOP (C) and SAP (D) excluding the blind spot.

**Figure 8.** Box plots showing the relationship between threshold sensitivity and eccentricity of test points from SAP (A) and SVOP (B) tests.

Supplemental Digital Content 1.pdf
Table 1. Demographic and clinical details of all participants included in the study.

| Age          | 65.9 ± 10.1 |
|--------------|-------------|
| **Number of participants by age range** |             |
| 40 to 49 years | 8 (8.2%)    |
| 50 to 59 years | 14 (14.4%)  |
| 60 to 69 years | 41 (87.2%)  |
| 70 to 79 years | 25 (25.8%)  |
| 80 to 89 years | 9 (19.1%)   |
| **Gender**   | 59 (60.8%) female |
| **SAP mean deviation** | -0.87 ± 1.56 (median -0.69, IQ range -1.92 to 1.53) |
| **Average SAP sensitivity (dB)** | 29.20 ± 1.68 (median 29.23, IQ range 28.23 to 30.47) |
| **Average SVOP sensitivity (dB)** | 32.18 ± 1.96 (median 32.58, IQ range 31.16 to 33.62) |
| **SAP test duration (s)** | 307 ± 42 (median 297, IQ range 281 to 329) |
| **SVOP test duration (s)** | 431 ± 110 (median 390, IQ range 354 to 461) |
### Table A

| Constant Coefficient | 34.74  | 34.66  | 36.15  | 35.5  |
|-----------------------|--------|--------|--------|-------|
|                       | -0.08  | -0.07  | -0.10  | -0.09 |
|                       | 0.04   | 0.03   | 0.06   | 0.09  |
|                       | 37.78  | 40.58  | 37.7   | 38.61 |
|                       | -0.13  | -0.14  | -0.09  | -0.12 |
|                       | 0.13   | 0.18   | 0.04   | 0.08  |
|                       | 37.82  | 39.82  | 40.63  | 40.89 |
|                       | -0.11  | -0.13  | -0.12  | -0.13 |
|                       | 0.08   | 0.16   | 0.16   | 0.19  |
|                       | 37.82  | 39.82  | 40.63  | 40.89 |
|                       | -0.11  | -0.13  | -0.12  | -0.13 |
|                       | 0.08   | 0.16   | 0.16   | 0.19  |
|                       | 37.82  | 39.82  | 40.63  | 40.89 |
|                       | -0.11  | -0.13  | -0.12  | -0.13 |
|                       | 0.08   | 0.16   | 0.16   | 0.19  |

### Table B

|          | 30.74 | 31.16 | 31.15 | 31.0  |
|----------|-------|-------|-------|-------|
| 31.28   | 33.58 | 33.20 | 32.61 | 32.22 |
| 32.32   | 33.32 | 34.63 | 34.39 | 34.49 |
| 31.59   | 34.01 | 35.43 | 35.17 | 36.29 |
| 32.77   | 33.63 | 34.63 | 35.53 | 36.32 |
| 32.88   | 34.62 | 34.94 | 35.18 | 35.31 |
| 32.38   | 33.65 | 33.42 | 31.87 | 33.38 |
| 30.10   | 31.77 | 31.29 | 30.04 |       |

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### Table A

| Constant | Coefficient R² |
|----------|----------------|
| 35.71    | 0.12           |
| 34.48    | 0.21           |
| 33.98    | 0.07           |
| 33.42    | 0.09           |
| 35.78    | 0.13           |
| 35.39    | 0.22           |
| 37.13    | -0.10          |
| 35.54    | -0.09          |
| 35.23    | -0.06          |
| 34.24    | -0.08          |
| 34.89    | -0.08          |
| 35.77    | -0.12          |
| 35.69    | 0.14           |
| 35.79    | -0.17          |
| 38.83    | -0.18          |
| 38.99    | -0.14          |
| 35.67    | -0.23          |
| 35.73    | -0.01          |
| 38.4     | -0.17          |
| 36.65    | 0.22           |
| 33.72    | 0.24           |
| 39.1     | 0.24           |
| 43.28    | 0.17           |
| 37.94    | 0.13           |
| 37.39    | -0.06          |
| 35.75    | -0.12          |
| 35.27    | -0.12          |
| 37.64    | -0.09          |
| 36.67    | 0.15           |
| 38.50    | 0.15           |
| 36.68    | 0.22           |
| 34.73    | 0.06           |
| 36.92    | -0.09          |
| 34.46    | -0.12          |
| 34.03    | 0.23           |
| 34.43    | 0.22           |
| 33.7     | 0.22           |
| 37.89    | 0.10           |
| 35.53    | 0.10           |
| 40.38    | -0.15          |
| 36.61    | 0.16           |
| 37.74    | 0.13           |
| 38.25    | 0.19           |
| 33.2     | 0.19           |
| 35.53    | 0.10           |

### Table B

|          | 27.68 | 29.34 | 26.51 | 28.00 |
|----------|-------|-------|-------|-------|
| 26.71    | 29.48 | 29.48 | 28.92 | 29.78 |
| 29.13    | 30.54 | 31.73 | 31.24 | 30.89 |
| 28.79    | 29.83 | 31.89 | 32.17 | 32.73 |
| 29.28    | 29.94 | 31.89 | 32.75 | 33.27 |
| 29.18    | 31.23 | 32.42 | 31.96 | 31.53 |
| 30.88    | 31.11 | 31.24 | 30.75 | 30.70 |
| 29.40    | 29.60 | 29.81 | 29.52 |       |

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|   | 3.06 | 1.82 | 4.64 | 3.00 |
|---|------|------|------|------|
| 2.57 | 4.10 | 3.72 | 3.69 | 2.44 | 3.87 |
| 3.19 | 2.78 | 2.90 | 3.15 | 3.6  | 2.61 | 3.54 | 3.25 |
| 2.80 | 4.18 | 2.32 | 3.26 | 2.44 | 3.39 | 3.81 | 4.44 | 1.85 |
| 3.49 | 3.69 | 2.74 | 2.78 | 3.05 | 2.19 | 2.63 | -0.24 |
| 3.70 | 3.39 | 2.52 | 3.22 | 3.78 | 2.61 | 2.49 | 2.61 |
| 1.50 | 2.54 | 2.18 | 1.12 | 2.68 | 3.06 |
| 0.70 | 2.17 | 1.48 | 0.52 |
Supplementary Figure 1. Bland Altman plot showing relationship between paired differences and their average for average SVOP and average SAP sensitivities for healthy participants for left eyes.
Supplementary Figure 2. Scatter plots showing the relationship between average SAP sensitivity and age (A) and average SVOP sensitivity and age (B) for left eyes. Average SAP sensitivity decreased by 0.06 dB (95% CI 0.03 to 0.09, P<0.001, R² = 0.190) per year older. Average SVOP sensitivity decreased by 0.10 dB (95% CI 0.07 to 0.13, P<0.001, R² = 0.388) per year older.
**Supplementary Figure 3.** Box plots showing the relationship between threshold sensitivity and eccentricity of test points from SAP (A) and SVOP (B) tests for left eyes. For SAP, there was a 0.295 dB (95% CI 0.274 to 0.317, $R^2 = 0.145$) decrease in threshold sensitivity per degree increase in eccentricity. For SVOP there was a 0.183 (95% CI 0.164 to 0.202, $R^2 = 0.076$) decrease in threshold per degree increase in eccentricity.