SITA Standard in Optic Neuropathies and Hemianopias: A Comparison with Full Threshold Testing

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PURPOSE. To compare visual sensitivity, fatigue effect, and probability plot data between Full Threshold (FT) Humphrey automated perimetry and Swedish Interactive Threshold Algorithm (SITA) standard strategies in patients with optic neuropathies and hemianopias.

METHODS. Twenty-four patients with nonglaucomatous optic neuropathies and 18 patients with a relative homonymous or bitemporal hemianopia were tested with both conventional perimetry (Humphrey 24-2 program) and “back to back” SITA standard tests (SITA 1, SITA 2) to approximate the test time of the FT test conditions. Also, 28 normal subjects between the ages of 20 and 80 were tested with this protocol. The visual field quadrants with the most damage were used to evaluate any fatigue effect (i.e., possible lack of fatigue effect with SITA standard due to the shorter test time) and to compare probability plot data between FT, SITA 1, and SITA 2. Pointwise total and pattern deviation probability plot defects were weighted by degree of significance and summed.

RESULTS. Test times for normal subjects were 45 seconds longer for FT than for the combined test time of SITA 1 + SITA 2. Patients’ test times were 40 seconds longer for hemianopias and 90 seconds longer for optic neuropathies with FT than for the combined times for two SITA tests. There were higher sensitivities found with SITA 1 compared with Full Threshold (1.06 dB, P < 0.001) and SITA 2 with Full Threshold (0.73 dB, P < 0.001) in the most damaged quadrant for the optic neuropathy patients; for the hemianopia patients the difference in values were between SITA 1 and Full Threshold (0.96 dB, P = 0.07) and between SITA 2 and Full Threshold (0.11 dB, P = 0.87). The second SITA standard test had lower sensitivity than the first SITA standard test by 0.82 dB in hemianopias and by 0.71 dB in optic neuropathy patients. Analysis of the total and pattern deviation probability plot data showed slightly more defects (number and magnitude) with SITA 1 compared to FT for both groups, but the differences were not statistically significant.

CONCLUSIONS. Sensitivities were higher in patients with hemianopias or optic neuropathies using SITA standard compared with FT by approximately 1 dB. The probability plot comparison suggests SITA standard is at least as good as FT for detection of visual loss in individual examinations. However, efficacy of SITA standard for serial examinations has not yet been evaluated. (Invest Ophthalmol Vis Sci. 2001;42:528–537)

Automated perimetry was introduced to the clinic in the early 1980s. It provides a standardized testing method and improved quantitative measurement of peripheral visual function. Seventy-two locations in the visual field are typically tested using a six-degree, spaced grid, offset at the vertical and horizontal meridians. Conventional testing uses a 4 dB/2 dB staircase procedure (full threshold algorithm). Fixation accuracy is measured either using an eye monitor/tracker or the Heijl–Krakow blind spot trial method. Reliability is tested with measurement of false positive and false negative catch trials and double threshold determinations. This results in test times in normals of approximately 10 minutes and 10 to 20 minutes per eye in patients with moderate visual loss. Single crossing of threshold (Fastpac) and the Dynamic Strategy of Weber have been used to shorten the test time with some success. However, the boring nature of the task, coupled with the long test time, is the source of visual fatigue, testing artifacts, and many patient complaints. To reduce the test time of automated perimetry further, Humphrey Instruments, over a 10-year period, developed Swedish Interactive Threshold Algorithm (SITA), a new test methodology.

SITA is a method of estimating thresholds and reliability indices that has been optimized for a reduction in test time.1–5 To accomplish this reduction in test time, information from surrounding test locations is used to compute staircase starting values. This is done by visual field modeling (normal and glaucoma models), using frequency of seeing curves, and by application of a Bayesian posterior probability function. When a predetermined level of uncertainty is reached (error related factor) the 4/2 staircase procedure is interrupted. Test time is further reduced both by test pacing that changes stimulus presentation rate in response to the patient’s reaction time and by a new method of calculating catch trials, mostly from data within the test. SITA is available for the Humphrey Field Analyzer in two versions. SITA standard is analogous to the Full Threshold strategy and uses a double crossing of threshold; SITA fast is analogous to Fastpac and adopts a single crossing of threshold using a 3-dB step. SITA permits a halving of the examination time while maintaining within-test variability at about the same level as the Full Threshold test done with the classic staircase procedure.2

Validation of this new methodology for detection of visual loss has been performed in normals and glaucoma patients.1–3,8 It has been observed that sensitivities are 1 to 2 dB higher than with conventional testing.8–11 The reason for this is unclear. Although visual fatigue has been suggested, evidence to the contrary exists.8 Shiraro and co-workers point out that the test point starting value affects the threshold estimate when using a 4/2 staircase,12 especially in subjects with moderate visual loss. They suggest differences in starting values may contribute to the higher SITA sensitivities. Also, SITA interrupts the staircase procedure when a predetermined level of uncertainty is surpassed. Because starting values are often higher than the true thresholds (the seed point starts at 25 dB), this staircase

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interrupting strategy may account for some of the higher sensitivities found with SITA. Also, confidence limits of normals are of smaller magnitude (require less sensitivity loss to be abnormal) with SITA standard (SITA standard) than with FT. Therefore, although sensitivities are higher, pointwise probability plot analysis appears to be comparable to standard 4/2-staircase testing (Statpac 2).

SITA was developed for visual field testing in glaucoma patients and has not been validated in other visual disorders, specifically neuro-ophtalmologic ones. Our goal was two-fold. First, we aimed to determine whether this test strategy was valid in patients with nonglaucomatous optic neuropathies and hemianopias. Second, we wished to investigate further whether the higher sensitivities found with SITA standard were attributable to less visual fatigue.

**METHODS**

**Subjects**

The visual testing protocol was approved by the University of Iowa Investigational Review Board. The tenets of the Declaration of Helsinki were followed. Sixty-six subjects participated in the study. Twenty-eight were normal subjects, 18 patients had hemianopias, and 24 patients had nonglaucomatous optic neuropathies. Of those with an optic neuropathy, six had idiopathic intracranial hypertension, five had anterior ischemic optic neuropathy and 13 had optic neuritis. In the 18 patients with hemianopias, a bitemporal hemianopia, homonymous hemianopia, or a homonymous quadrantanopia was present. There were 2 patients with pituitary tumors (bitemporal hemianopia), 8 patients with stroke, and 6 patients who had undergone a temporal lobectomy. One patient had a homonymous hemianopia due to a hemispherectomy. In another, the homonymous hemianopia was considered to be a congenital defect. They all gave informed consent to participate in the study. The patients had various degrees of visual damage from mild to severe. Most of the normal subjects were paid volunteers who were hospital employees, friends, or family members of eye clinic patients. Five normal subjects were tested per decade from ages 20 to 70 with three normals tested from the eighth decade. Nineteen normal subjects were women and nine were men. Ten of the 28 normals (approximately 2 per decade) were naive perimetry subjects. The mean age of the hemianopia patients was 49.1 ± 15.2 years and the patients with non-glaucomatous optic neuropathies, 40.3 ± 14.1 years.

Normal subjects were included if they had no history of eye disease except refractive error (no more optical correction than five diopters of sphere or three diopters of cylinder); no history of diabetes mellitus or systemic arterial hypertension; a normal ophthalmologic examination including 20/25 or better Snellen acuity; and normal automated perimetry results (Humphrey Visual Field Analyzer, program 24-2). If a potential normal subject had three or more adjacent abnormal points in a clinically suspicious area at the P < 0.05 level, or two adjacent points abnormal with at least one at the P < 0.01 level, or a mean deviation that fell outside the 95% confidence limit, they were excluded. The included subjects had either undergone a complete eye examination within 12 months before this study or were examined by an ophthalmologist on the day of testing to ensure normal ocular health. The visual field inclusion criteria were based on the conventional perimetry examination done for this study.

The patients were selected by a chart review or were asked to participate as part of a scheduled clinic visit. They all fulfilled the following inclusion criteria: best-corrected acuity of 20/40 or better; objective evidence of an optic neuropathy or hemianopia; ages 20 to 70 years; and acceptable reliability indices (based on manufacturer’s recommendations) on the Humphrey Full Threshold visual field examinations. Patients were excluded if they had any other disease causing visual field loss, including systemic arterial hypertension or diabetes mellitus severe enough to cause retinopathy, media opacity severe enough to interfere with visualization of the optic disc, a history of mental illness, or cancer with metastases.

**Visual Testing**

All subjects first underwent standard Humphrey 24-2 Full Threshold testing. We followed the manufacturer’s recommendations and used a corrective lens when necessary. Care was taken to prevent lens rim
artifact. The 24-2 Full Threshold test was administered to all normal subjects and to patients who had a stable visual field within 1 year of this study. Normals and optic neuropathy patients had testing in one eye. Halfway through the Full Threshold test, the normals and the patients were given a 2-minute rest break. Normals had their right eye tested, and patients with optic neuropathies had either an involved eye chosen randomly or one with mild–moderate rather than severe loss. Only one eye was tested because often the second eye had normal function. Hemianopia patients had both eyes tested (2 Full Threshold tests and 4 SITA tests).

SITA standard testing was done after the 24-2 testing as follows. All subjects had two SITA standard examinations in continuity for the eye being tested. A 2-minute break was given between tests while the examiner reset the computer (2 minutes is the approximate time needed for resetting for a repeat test). The hemianopia patients had both eyes tested (2 Full Threshold tests and 4 SITA tests).

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Statistical Analysis
We compared test times for FT, SITA 1, and SITA 2. A repeated measures analysis of variance (ANOVA) was used to compare sensitivities among the tests. A $6 \times 3$ (age, test) split-plot ANOVA was used in the normals to test for effects of age; a $4 \times 3$ (zone, test) repeated measures ANOVA was used to test for eccentric zone effects. The zones were four areas approximately $6^\circ$ apart with values from the blind spot ($15, 3$ and $15, -3$) excluded. Zone 1 was the innermost and Zone 4 the outermost area.

For statistical analysis of patients, we chose the thresholds from the most damaged quadrant for analyses; we defined this as the quadrant with the lowest sensitivity mean score. This was done because with the hemianopia patients, at least two of the other three quadrants could be normal. For the total and pattern deviation probability plot analyses, results were weighted point-by-point and summed. This was done for all test locations for the optic neuropathy patients and for the involved hemifield in the hemianopia patients. We assigned weighting values to the probability plot results as suggested by Asman and colleagues: a $P$ value of 5% was assigned a value of $2$, $2\%$ to $5\%$ a value of $3$, $1\%$ to $10\%$ a value of $5$, and $0.5\%$ to $2\%$ a value of $10$.34 We then summed these weighted values for each patient for a probability score.

Differences among groups were tested for significance with ANOVA. Differences between groups of all test results were interpreted as significant if the probability of their occurrence was less than 0.05.

Results
Examination test times in minutes for normal subjects with Full Threshold testing were $9.87 \pm 0.76$, $4.59 \pm 0.56$ for SITA 1, and $4.54 \pm 0.37$ for SITA 2. There was a $54\%$ reduction of test time with SITA standard in normals. Test times in minutes for optic neuropathy patients with Full Threshold testing were
There was a 46% reduction in test time with the SITA standard method for the optic neuropathy patients. For the hemianopia patients, the mean test time in minutes for Full Threshold testing was 10.67 ± 1.45. For SITA 1, it was 6.14 ± 0.66 and for SITA 2, 6.23 ± 0.68. This represents a 40% reduction in test time. Test times were 45 seconds longer for Full Threshold than SITA 1 + SITA 2. Patients’ test times for the first two tests combined averaged 40 seconds longer for hemianopias and 90 seconds longer for optic neuropathies. The test times, mean deviation, pattern SD, corrected pattern SD, and short-term fluctuations are found in Table 1 for the three groups. Examples of individual normal (Fig. 1A), optic neuropathy (Fig. 1B, 1C, 1D), and hemianopia (Fig. 1E) patient results are shown.

There were higher sensitivities found with SITA 1 compared with Full Threshold (1.06 dB, \( P < 0.001 \)) and SITA 2 with Full Threshold (0.75 dB, \( P < 0.001 \)) in the most damaged quadrant for the optic neuropathy patients; for the hemianopia patients the difference in values were between SITA 1 and Full Threshold (0.96 dB, \( P = 0.07 \)) and between SITA 2 and Full Threshold (0.11 dB, \( P = 0.87 \)). The comparisons of the mean deviation along with the values for pattern SD, corrected pattern SD, and short-term fluctuation (SF) for all groups are found in Table 1. The second SITA standard test had lower sensitivity than the first SITA standard test by 0.82 dB in hemianopias and by 0.71 dB in optic neuropathy patients. This suggests about a 3/4 dB fatigue effect.

However, when individual subjects were analyzed for a fatigue effect, whether it was a within- or between-algorithm effect, the following was apparent. In some patients, the mean deviation of SITA 1 was worse (i.e., more negative) than the MD of SITA 2, indicating that the opposite of the expected fatigue effect was present. This occurred in 8 of 28 normals (27.6%). If the MD of SITA 1 was more negative than that of FT, then again, there would also be no evidence for a fatigue effect in that patient. We found a lack of fatigue effect using these criteria (SITA 2 sensitivity higher than SITA 1 or Full Threshold sensitivity higher than SITA 1) in 9 of 28 normals (31.1%). Thirteen of 28 normals (46.4%) met either of these conditions.

For the optic neuropathy patients, lack of fatigue effect was found in 29.2%, 33.5%, and 45.8% of patients meeting one, the other, or either criteria. For the right eyes of the hemianopia patients, these results were: 18%, 50%, and 69% as evidence against a fatigue effect. Therefore, although there is evidence for a between-algorithm fatigue effect, the effect is overshadowed by another process in many of the patients; this process is likely retest variability. In the hemianopia patients, 11 of 18 patients had areas of absolute loss in their hemianopic fields. This took the form of full quadrant loss in 5, partial quadrant(s) loss in 5, and hemifield loss in 1. These areas of absolute loss likely contributed to inability to demonstrate any evidence of a fatigue effect.

We also analyzed the SITA 1 versus SITA 2 data on a point-by-point basis (SITA 1 test location result minus SITA 2 result). The data for normals by age are shown in Figures 2 and 3a. The split-plot ANOVA \( (6 \times 5; \text{age} \times \text{test}) \) yielded significant main effects for age \( [F(5,25) = 6.297, P < 0.001] \); power (\( \alpha = 0.05 \)) of 0.96] and test \( [F(2,46) = 57.178, P < 0.001] \); power (\( \alpha = 0.05 \)) of 1.00]; the interaction was also significant \([F(10,46) = 2.373, P = 0.023] \); power (\( \alpha = 0.05 \)) of 0.61]). The expected small decrease in sensitivity with age was observed, but there appears to be little effect of age on the differences. Only for the 60-year-olds were SITA 1 (31.0) and SITA 2 (30.4) significantly different. For the 30-, 40-, 50-, and 60-year-olds, Full Threshold was lower than both SITA 1 and SITA 2; for the 20-year-olds, Full Threshold was only lower than S1, and only lower than S2 for the 70-year-olds.

The data for patients are found in Figures 3b and 3c, showing the substantial increase in variability with a loss of sensitivity in both patient groups. Figures 4a and 4b shows a pointwise comparison of Full Threshold and SITA 1 results (a) and SITA 1 vs. SITA 2 results. This figure shows tests from one eye on 24 nonglaucomatous optic neuropathy patients with values for the blind spot removed (coordinates 15,3 and 15,2) and a 45°-angle line of perfect agreement between the sensitivity values of the two tests. Note that there is considerable retest variability on a pointwise basis, but when comparing the overall graphs of SITA 1 and Full Threshold compared with SITA 1 versus SITA 2, the two graphs are similar. The variability between tests increases markedly with lower sensitivity and then lessens near 0 dB (floor effect).
A prominent finding was that there was a high correlation between the average threshold of the quadrants comparing the results from SITA 1, SITA 2, and Full Threshold testing (Fig. 5). Therefore although the comparison of individual test locations using each test was highly variable in the damaged areas, the groups of points together (quadrant averages) dampen the effect of this variability. At least some of the high \( r^2 \) values, though, for the patients displayed in Figure 5 are due to areas of absolute loss.

We analyzed our normal subjects’ data by repeated measures ANOVA (4 \( \times \) 3: zone \( \times \) test). This yielded significant main effects for zone \([F(3,84) = 297.92, P < 0.001; \text{power} (\alpha = 0.05) = 1.00]\) and test \([F(2,56) = 47.702, P < 0.001; \text{power} (\alpha = 0.05) = 1.00]\); the interaction was also significant \([F(6168) = 3.401, P = 0.003; \text{power} (\alpha = 0.05) = 0.812]\). The eccentric zone data are found in Table 2. Thresholds between the two SITA tests did not differ significantly at the three innermost zones (SITA 1 had higher sensitivities by 0.12 in Zone 1, central, 0.23 in Zone 2, and 0.19 in Zone 3), but thresholds on the Full Threshold test were significantly lower than for both SITA tests. However, at the outermost eccentricity, Zone 4, thresholds on the second SITA test were signifi-
SITA accomplishes threshold estimations by calculating Bayes-

**DISCUSSION**

were greatest in the periphery. Therefore, the differences in sensitivity between the two tests significantly lower by 0.38 dB than thresholds on the first SITA test. Figure 4. (A) Pointwise comparisons of the three tests in the optic nerve neuropathy patients showing SITA 1 vs Full Threshold and (B) SITA 1 compared with SITA 2. The 45°-angle line represents perfect agreement, drawn for comparison, between the two tests. Note the two graphs are similar with an increase in variability as sensitivity lessens.

Analysis of the total and pattern probability plot data showed slightly more defects (number and magnitude) with SITA 1 compared to Full Threshold for both groups, but the differences were not statistically significant (Fig. 6). Note the similarity of right and left eyes in the hemianopia patients due to the high congruity of many of the visual field defects (Fig. 6B, 6C).

**FIGURE 4.** (A) Pointwise comparisons of the three tests in the optic nerve neuropathy patients showing SITA 1 vs Full Threshold and (B) SITA 1 compared with SITA 2. The 45°-angle line represents perfect agreement, drawn for comparison, between the two tests. Note the two graphs are similar with an increase in variability as sensitivity lessens.

SITA Standard Perimetry in Neuro-Ophthalmologic Disorders

normal and glaucoma visual field models. But, what if the patient’s visual system damage is not due to glaucoma? Many optic neuropathies have visual field defect topography similar to glaucoma. One would predict that Full Threshold testing and SITA results would have good agreement in patients with idiopathic intracranial hypertension, anterior ischemic optic neuropathy, and optic nerve head drusen, as the visual field defects in these disease processes are similar. Many patients with optic neuritis and compressive or traumatic optic neuropathies also have nerve fiber bundle-like defects that should be correctly plotted by the SITA models. However, correlations between test locations based on glaucomatous damage might be anticipated to cause artifacts or result in failure to detect defects in patients with these disorders having central or cecocentral scotomas; our results show that this does not appear to be the case. In our patients with nonglaucomatous optic neuropathies, the SITA standard strategy did not miss any significant defects.

Patients with hemianopias present a different problem. Here, defects nearly always respect the vertical meridian rather than fitting nerve fiber bundle-like patterns. We were much more concerned that SITA standard might have some problems in estimating thresholds in patients with hemianopic defects. Again, we found no evidence that neurologic defects were missed by SITA standard.

We believe SITA standard worked well in detecting neurologic defects because the basic SITA model that estimates threshold (the normal and glaucoma model in conjunction with frequency of seeing curve data) is likely similar to a model based on neurologic defects. Frequency of seeing curve data does not appear to be disease specific, rather it varies with threshold. Also, the use of correlations between test locations, expected to be present in a glaucomatous visual field, does not appear to be a major factor in the algorithm because we did not encounter any instances of loss of definition of hemianopic defects due to glaucoma-related correlations across the vertical midline.

It is well established that SITA standard testing results in slightly higher sensitivity estimations than Full Threshold testing. This increase in sensitivity with SITA standard has been found to be independent of age and does not appear to be dependent on test point position. Its relationship to test point threshold has been studied with conflicting results. Table 3 summarizes these differences in sensitivity reported in normals and glaucoma patients. SITA standard testing resulted in higher sensitivities in all comparisons. In normals, the range is from 0.8 to 1.6 dB with a mean of 1.2 dB. In glaucoma patients, the range is from 1.0 to 2.5 dB with a mean of 1.5 dB. Our 0.44 dB (0.24 dB for normals, 0.57 dB for optic neuropathy, and 0.05 dB for hemianopia patients) increase with SITA 1 compared to Full Threshold is considerably less than these other studies. The difference might relate in part to the procedure in our study to do Full Threshold testing first. A small fatigue effect is possible, but the patients had at least a 15-minute break between the two tests. Additionally, the small difference in hemianopia patients may be attributable to the frequent presence of absolute sensitivity loss.

The reason for this increase in sensitivity with SITA standard is likely an interaction of factors. Bengtsson and Heijl attribute this difference to visual fatigue; and our study suggests that at least some of this effect is related to visual fatigue. Shirato and co-workers speculated that in addition to fatigue, the increase in sensitivity might relate to differences in starting values for the staircase procedure. Also, SITA interrupts the staircase procedure when a predetermined level of uncertainty (the error related factor) is surpassed. Because starting values are usually higher than the true thresholds, we agree that this...
may account for some of the higher sensitivity found with SITA.

The goal of the SITA algorithms is to reduce test time without sacrificing sensitivity for detection of defects or without raising retest variability. The studies to date reporting test-time reduction are summarized in Table 3. Wild et al.11 found a 53% shorter test time for SITA standard than for Full Threshold testing. Examination time duration increased with visual field damage. Our results are similar to these other studies with a 54% reduction of test time with SITA standard in normals; a 46% reduction in test time with the SITA standard method for the optic neuropathy patients; and, a 40% reduction in test time for hemianopia patients.

Bengtsson and Heijl investigated intersubject variability and the normal limits of SITA standard in 330 eyes of 330 normal subjects.9 They found a 31% decrease in intersubject variance with SITA standard compared with Full Threshold testing. This translated into a tightening of the confidence limits of normality from 9 to 29%; that is, the average sensitivity depressions needed to reach the 5% and smaller limits were modestly reduced. This finding is in concert with our observation that there is not much difference when comparing probability plot data between SITA standard and Full Threshold results in patients with neuro-ophthalmologic disorders.

Wild and colleagues16 showed the pointwise between algorithm, between subject variability was lower with SITA standard. The mean of the ratio of the SD for SITA standard compared with Full Threshold for the 24-2 test locations was 0.93, demonstrating lower variability for SITA standard. Shirato and coworkers8 found the test-retest variability was slightly

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**Figure 5.** Comparison of mean quadrant scores of the quadrant with the lowest mean sensitivity (average quadrant score) for normals (A, B), optic neuropathy patients (C, D), and the right eye of hemianopia patients (E, F) with regression lines and $R^2$. Results for SITA 2 plotted against SITA 1 are found on the left and for SITA 2 compared with Full Threshold to the right. Note that in the normals (A, B) the slightly higher SITA 1 scores compared with SITA 2 and the slightly higher SITA 2 scores compared with Full Threshold quadrant results. These differences, if present, are less obvious in the patients.
lower with SITA standard than Full Threshold (2.9% vs. 3.4%). Our results, displayed graphically in Figure 5, also show similar variability of Full Threshold and SITA results. Wild and coworkers suggest that an interaction of the error related factor, the model for the normal island of vision and post-processing computations artificially smooth the visual field results, thereby lowering the between-subject variability.16

Bengtsson and Heijl compared probability plot results between Full Threshold and SITA strategies.13 They tested one eye of 44 glaucoma patients four times with each strategy. Another 21 eyes of 21 normal subjects were examined once with each strategy. The magnitude of field loss as defined by the Statpac Mean Deviation did not differ between the strategies. However, in the glaucoma patients, SITA showed a slightly larger number of significantly depressed points in the probability maps compared to the Full Threshold strategy. They concluded that SITA standard (and also SITA fast) identified at least as many significant glaucomatous field defects as

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**FT**, Full threshold; **SITA 1**, first SITA test; **SITA 2**, second SITA test; **AVG**, average.
the Full Threshold strategy. Wild and co-workers compared the variability of the SITA algorithm’s test results with those of Fastpac and Full Threshold testing in patients with primary open angle glaucoma. They studied one eye from each of 29 patients. Unlike our study, the total deviation probability plot analysis showed a statistically greater number of defects with SITA standard than with Full Threshold testing. Our findings, though, agree with these studies and extend the use of total and pattern deviation plot results to patients with nonglaucomatous optic neuropathies and hemianopias.

In aggregate, it is clear that SITA standard accomplishes its goal of a substantial reduction of test time in normals, glaucoma, and neuro-ophthalmology patients. The reduction in time is on the order of 50%. The test time is longer in patients than normals and the relative time savings is less, probably due to more error in estimating starting values in damaged visual fields. In the development of SITA standard, the error-related factor was chosen so that SITA standard would have a similar variability to Full Threshold testing. It appears that SITA standard has about the same retest variability compared to Full Threshold testing and that this algorithm does not solve this critical problem of variability increasing exponentially with decreasing threshold. Our results agree with those findings.

It is also clear that with SITA standard compared to Full Threshold testing, mean sensitivities are approximately 1 to 2 dB higher in normals, glaucoma subjects, and patients with other optic neuropathies and hemianopias. However, the

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<td></td>
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<tr>
<td>Shirato et al., 1999</td>
<td>80</td>
<td>80</td>
<td>1.0</td>
<td>49</td>
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<tr>
<td>Wild et al., 1999</td>
<td>29</td>
<td>29</td>
<td>1.0</td>
<td>49</td>
<td></td>
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<tr>
<td>Wall et al., 2000</td>
<td>24</td>
<td>24†, 18††</td>
<td>1.2</td>
<td>52.3</td>
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<tr>
<td>Totals</td>
<td>439</td>
<td>343</td>
<td>1.3</td>
<td>47.2</td>
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† Optic neuropathy patients.
†† Hemianopia patients.
mechanism of this difference is complex. Although some of this difference is due to visual fatigue, it is also likely that the SITA method, which interrupts the 4/2 staircase procedure when the error-related factor is reached, also contributes. However, from a clinical standpoint, the absolute differences are small and appear to be accounted for when comparisons are made to normative data from the two tests using the probability plot results.

The issue of fatigue is further complicated by the learning effect that works in the opposite direction with regard to sensitivity. The learning effect is the improvement in sensitivity found with repeated testing. In normal subjects, it is in the range of 1 to 2 dB21. There are three different patterns of sensitivity. The learning effect is primarily between the first and second visual fields. In some, there is a gradual learning effect over many visual fields. A substantial effect is found in a second visual fields. In some, the learning effect is primarily between the first and second exami-

nations but can continue for many with most of the effect in the first five examinations.21 and the effect may disappear after 5 months.23 In our study, this learning effect likely had some contribution tending to offset fatigue effects.

This study has several potential drawbacks. We were unable to reset the computer to do the second SITA test in less than about 2 minutes. This duration of a rest break likely reduced the effect of visual fatigue. Also, the high variability in patients with visual field damage made calculations of amount of sensitivity difference between the second SITA test and the Full Threshold results problematic. Lastly, the confounding influence of a learning effect likely interferes with our analysis of the effects of visual fatigue.

SITA represents a major advance in clinical perimetry. The substantial reduction in test time coupled with no apparent degradation of detection of visual loss is welcome. However, it remains unknown whether SITA will be as good or better than the Humphrey Full Threshold testing for detecting visual field progression. Studies addressing this issue are needed before full adoption of SITA takes place.

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