The SITA Perimetric Threshold Algorithms in Glaucoma

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PURPOSE. To determine the within-visit between-algorithm and the within-algorithm between-visit differences in sensitivity for the SITA Standard, SITA Fast, FASTPAC, and Full Threshold algorithms in stable primary open angle glaucoma.

METHODS. One designated eye from each of 29 patients (age 67.3 ± 10.2 years; mean ± SD) experienced in automated perimetry was examined with the four algorithms on each of three visits, using the Humphrey Field Analyzer 750 and Program 30-2.

RESULTS. The group mean Mean Sensitivity was 1.0 dB greater for SITA Standard than Full Threshold (P < 0.001), 0.7 dB greater for SITA Standard than FASTPAC (P < 0.001), 1.6 dB greater for SITA Fast than FASTPAC (P < 0.001), and 0.9 dB greater for SITA Fast than SITA Standard (P < 0.001).

The higher pointwise sensitivity for SITA Fast compared to Full Threshold, FASTPAC, and SITA Standard increased with increase in defect depth. The examination duration for SITA Standard was 53% of that for Full Threshold and 50% shorter for SITA Fast compared to FASTPAC (P < 0.001), regardless of age (P = 0.932). The examination duration increased with increase in severity of field loss (P < 0.001), and this increase was proportionately greater for both SITA algorithms (P < 0.001), particularly SITA Fast. The Total and Pattern Deviation probability analyses of both SITA algorithms yielded a statistically greater defect than Full Threshold or FASTPAC (P < 0.001). The within-algorithm between-visit differences were similar between SITA Standard and Full Threshold and between SITA Fast and FASTPAC.


Tatic threshold automated perimetry has become an essential component in the successful detection and management of primary open angle glaucoma (POAG). However, the length of the examination combined with the level of variability associated with the measurement of perimetric sensitivity is becoming incompatible with the increasing financial and resource constraints operative within health care provision.

The standard perimetric method for estimating threshold uses a staircase strategy in which the stimulus luminance is altered in either ascending or descending intervals until the threshold luminance for seeing is crossed.1 The accuracy of the staircase procedure at any given stimulus location primarily increases with the use of smaller steps when the staircase position is close to the threshold, with an increase in the number of crossings of threshold and with an increase in the number of staircases.2 However, the improvement in accuracy is at the expense of an increase in the examination duration.

The Full Threshold algorithm of the Humphrey Field Analyzer (HFA) uses an initial crossing of threshold in 4 dB increments and a final crossing in 2 dB increments. The final crossing occurs in either an ascending or descending direction and threshold is designated as the last seen stimulus luminance. The FASTPAC algorithm of the HFA uses a single crossing of threshold with a 3 dB step size, and threshold is also designated as the last seen stimulus luminance. The examination duration of the FASTPAC algorithm is approximately 35% shorter than that of the Full Threshold algorithm but is at the cost of an approximate 25% increase in the short-term fluctuation (i.e., the within-test variability) and an apparent underestimation of focal loss in glaucoma.3–7

A new generation of threshold algorithms, SITA (Swedish Interactive Threshold Algorithm), has become commercially available for the HFA Mark II,8,9 which represent an increase in statistical sophistication over previous algorithms. Two SITA algorithms are currently available, SITA Standard and SITA FAST, which are analogous to the Full Threshold and FASTPAC algorithms, respectively. Both SITA algorithms use two likelihood functions for each stimulus location, one for normal responses and one for glaucomatous responses. The likelihood functions are adjusted after the positive or negative response to each individual stimulus presentation, and the shape of the function alters with increase in the number of responses. At any given moment in the examination, the height of the function describes the most likely threshold value at the given location, and the width describes the accuracy of the threshold estimate. The SITA Standard algorithm uses a 4–2 dB step size and the SITA Fast algorithm a 4 dB step size. The thresholding procedure at any given location is halted when a predeter-
mined level of accuracy, as specified by the Error Related Factor, is obtained. At the end of the examination, the sensitivity at each stimulus location is recalculated using all the responses obtained from the examination. The resultant threshold is assumed to represent the stimulus luminance corresponding to a 50% probability on the frequency-of-seeing curve.

In the normal eye with Program 30-2, the SITA Standard algorithm has been found to be approximately 50% shorter and to yield a Mean Sensitivity index between 0.8 dB and 1.9 dB higher than the Full Threshold algorithm. The SITA Fast algorithm for Program 30-2 was 50% shorter than FASTPAC and yielded a Mean Sensitivity 1.5 dB higher. The between-algorithm differences did not alter with age. The higher Mean Sensitivities for SITA compared to the Full Threshold and FASTPAC algorithms are present despite correction for the systematic differences in the designation of threshold between the algorithms. Interestingly, the between-subject normal variability at each stimulus location and upon which the confidence limits for normality are related was found to be approximately 10% narrower for the SITA algorithms than for the Full Threshold and FASTPAC algorithms at those stimulus locations within the configuration of Program 24-2.

However, the magnitude of the threshold estimate and the outcome of the Total and the Pattern Deviation probability analysis with the SITA algorithms compared to the Full Threshold and FASTPAC algorithms in glaucoma is unknown. The extent of the reduction in the examination duration of the SITA algorithms in glaucoma is also unknown.

The aim of the study was to determine, in a cohort of patients with stable glaucoma, two performance criteria of the SITA Standard and SITA Fast algorithms compared to the Full Threshold and FASTPAC algorithms: (1) the within-visit between-algorithm differences in the examination duration, in the measured sensitivities, and in the Total and the Pattern Deviation probability values and (2) the within-algorithm between-visit differences in the measured sensitivities and in the Total and the Pattern Deviation probability values.

**METHODS**

The sample comprised 29 patients (19 male) with POAG. All patients manifested an optic nerve head appearance characteristic of POAG (including increase in cup size, increase in cup disc ratio, disc asymmetry, changes in the lamina cribrosa, loss of neuroretinal rim, pallor, evidence of peripapillary atrophy, vessel changes, or disc margin hemorrhage), together with a repeatable visual field defect consistent with POAG. The mean age of the sample was 67.3 years (SD ± 10.2, range 42–79 years). The inclusion criteria comprised a visual acuity of 6/9 or better in each eye; a distance refractive error less than or equal to 5 D mean sphere and less than 2.5 D cylinder; lenticular better in each eye; a distance refractive error less than or equal 3.4 mm Hg; mean ± SD) and between the second and third visit was 8 days (SD ± 3.4). Each visit comprised two sessions. At one session, the patients were examined with the Full Threshold and SITA Fast algorithms and at the second session with the FASTPAC and SITA Standard algorithms. Each session was separated by a rest period of 45 minutes. The order of algorithm within a session and the order of the sessions were randomized between patients but were held constant within a patient over each of the three visits. All patients were fully corrected, in trial lens form, for the viewing distance of the perimeter, and perimetry was performed according to standardized procedures. The results were obtained with software revision A9. The first visit was considered as a familiarization period and the results were discarded before commencement of the remaining two visits. The research followed the tenets of the Declaration of Helsinki, informed consent was obtained from the subjects after explanation of the nature and possible consequences of the study, and the study was approved by the Aston University Human Science Ethical Committee and the Birmingham Heartlands Research and Ethics Committee.

**Analysis**

The results in left eye format were converted to right eye format. The two stimulus locations immediately above and below the blind spot were omitted from the analysis. The data were analyzed in three separate ways.

For the first analysis, the differences in the examination duration and in each of the visual field indices Mean Sensitivity (MS), Mean Deviation (MD), and Pattern Standard Deviation (PSD) between the four algorithms within each of the remaining two visits and the differences within-algorithm between-visits were analyzed using separate repeated measures Analysis of Variances (ANOVA) for a four-period crossover trial within visit and with the treatment sequence being replicated at the second visit. The age of the patient and the severity of the visual field were considered as separate between-subject factors. The type of algorithm, the order of the two sessions, and the order of presentation of the algorithm within a session were considered as separate within-subject factors. The Short-term Fluctuation (SF) and therefore the Corrected Pattern Stan-
dard Deviation (CPSD) are not calculated by the SITA algorithms.

Based on an expected range of differences in MS of ±3 dB (range 6 dB) between-algorithms within-visit and also within-algorithm between-visits, the SD of the differences was estimated to be approximately 1.5 dB (4 SD being 95% of the distribution). A sample of 26 subjects would therefore have provided 90% power of detecting a 1.0 dB difference, between-algorithms within-visit and within-algorithm between-visits, at the 5% significance level. A difference in MS of 1.0 dB or less was not considered clinically significant. Although all factors in the ANOVA models were tested for statistical significance, it was accepted that the higher order interactions would possess reduced power because of the sample size used. However, the sample size was still considered sufficiently adequate to detect clinically important differences involving the higher order interactions.

For the second analysis, the difference in sensitivity at each stimulus location across all patients between each pair of algorithms at the second visit (i.e., the within-visit between-algorithm variability) was calculated and expressed as a function of the sensitivity at the given stimulus location recorded at the same visit with the comparison algorithm of the given pair. Similarly, the difference in sensitivity at each stimulus location across all patients for a given algorithm between the second and third visits (i.e., the within-algorithm between-visit variability) was calculated and expressed as a function of the sensitivity recorded at the second visit at the given stimulus location with the given algorithm.

For the third analysis, the within-visit between-algorithm differences in the Total Deviation probability values at each stimulus location across all 29 patients at visit 2 was expressed as a 5 × 5 contingency table for each pair of algorithms. This procedure then was repeated for the Pattern Deviation Probability values. Identical analyses were undertaken for the within-algorithm between-visit differences in the Total and in the Pattern Deviation probability values between the second and third visits. The differences in the distribution of values for each within-visit between-algorithm comparison and for each within-algorithm between-visit comparison were then analyzed using separate Wilcoxon signed-rank tests.

RESULTS

Global Indices

The group mean MS was independent of age (P = 0.754). The group mean MS varied as function of algorithm (P < 0.001), regardless of visit (P = 0.541); the SITA Standard group mean MS was 1.0 dB higher than the Full Threshold MS and 0.7 dB higher than the FASTPAC MS. The SITA Fast group mean MS was 1.6 dB higher than FASTPAC and 0.9 dB higher than that of the SITA Standard. Group mean MS declined as a function of the severity of field loss (P < 0.001), irrespective of algorithm (P = 0.052). The differences in the MSs between the four algorithms were similar between visits (P = 0.956) and were also independent of age (P = 0.800). Group mean MS varied as a function of order of test (P < 0.001), and this order effect was different between tests (P = 0.01). The subgroup mean MS for the Full Threshold algorithm and for the SITA Standard algorithm was lower when the algorithms were undertaken as the second test at any given session, whereas that for the FASTPAC algorithm was higher as the second test of any session.

The group mean MD was independent of age (P = 0.075). It was similar for all four algorithms (P = 0.291) regardless of visit (P = 0.961). The Group mean MD became more negative as a function of the severity of field loss (P < 0.001), irrespective of algorithm (P = 0.577). It varied as a function of order of test (P < 0.001), and this order effect was different between tests (P = 0.004). The subgroup mean MD for the Full Threshold algorithm and for the SITA Standard algorithm was more negative when the algorithms were undertaken as the second test at any given session, whereas that for the FASTPAC algorithm was less negative as the second test of any session.

Table 1. The Group Mean for each of the Global Indices and for Examination Duration for the Full Threshold, FASTPAC, SITA Standard, and SITA Fast algorithms

<table>
<thead>
<tr>
<th>Index</th>
<th>Visit</th>
<th>Full Threshold</th>
<th>FASTPAC</th>
<th>SITA Standard</th>
<th>SITA Fast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Sensitivity (dB)</td>
<td>2</td>
<td>22.18 ± 4.32</td>
<td>22.38 ± 3.90</td>
<td>23.15 ± 4.77</td>
<td>24.05 ± 4.12</td>
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<tr>
<td></td>
<td>3</td>
<td>22.26 ± 4.43</td>
<td>22.54 ± 4.13</td>
<td>23.21 ± 4.71</td>
<td>24.04 ± 4.17</td>
</tr>
<tr>
<td>Mean Deviation (dB)</td>
<td>2</td>
<td>−4.97 ± 4.10</td>
<td>−4.98 ± 3.76</td>
<td>−5.11 ± 4.45</td>
<td>−4.88 ± 4.02</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>−4.94 ± 4.08</td>
<td>−5.09 ± 4.06</td>
<td>−5.20 ± 4.6</td>
<td>−4.77 ± 4.10</td>
</tr>
<tr>
<td>Pattern Standard Deviation (dB)</td>
<td>2</td>
<td>6.90 ± 3.82</td>
<td>6.68 ± 3.77</td>
<td>7.15 ± 4.45</td>
<td>6.79 ± 4.11</td>
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<tr>
<td></td>
<td>3</td>
<td>7.32 ± 3.88</td>
<td>6.77 ± 3.77</td>
<td>7.46 ± 4.31</td>
<td>6.42 ± 4.25</td>
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<td>Short-term Fluctuation (dB)</td>
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<td>1.85 ± 0.92</td>
<td>2.12 ± 0.77</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1.88 ± 1.24</td>
<td>2.26 ± 1.03</td>
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<td>—</td>
</tr>
<tr>
<td>Corrected Pattern Standard Deviation (dB)</td>
<td>2</td>
<td>6.16 ± 3.72</td>
<td>5.99 ± 4.19</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6.76 ± 4.02</td>
<td>5.78 ± 4.07</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Examination Duration (min)</td>
<td>2</td>
<td>15.04 ± 1.54</td>
<td>9.56 ± 1.40</td>
<td>8.03 ± 1.14</td>
<td>4.81 ± 0.93</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>14.89 ± 1.76</td>
<td>9.45 ± 1.37</td>
<td>7.78 ± 0.91</td>
<td>4.68 ± 0.85</td>
</tr>
</tbody>
</table>

Values are the group means ± 1 SD.
The group mean PSD decreased with increase in age ($P = 0.004$). It varied as function of algorithm ($P < 0.001$), regardless of visit ($P = 0.368$); the SITA Standard group mean PSD was approximately 0.2 dB higher than the Full Threshold PSD and approximately 0.6 dB higher than the FASTPAC PSD. The difference in the PSDs between algorithms increased as a function of the severity of field loss ($P < 0.001$); the SITA Standard subgroup mean PSD was 0.8 dB higher than the Full Threshold for the severe field loss category ($P = 0.002$). The differences in the PSD between the four algorithms were similar between visits ($P = 0.067$) and were also independent of age ($P = 0.763$). Group mean PSD varied as a function of order of test ($P < 0.001$), but this order effect was not noticeably different between tests ($P = 0.092$).

The examination duration was independent of age ($P = 0.284$). The group mean examination duration was approximately 53% shorter for the SITA Standard algorithm compared to the Full Threshold algorithm and approximately 50% shorter for the SITA Fast algorithm compared to the FASTPAC algorithm ($P < 0.001$), regardless of visit ($P = 0.145$) and of age ($P = 0.932$). The between-algorithm differences in group mean examination duration were similar between visits ($P = 0.967$). The duration increased as a function of the severity of field loss ($P < 0.001$), and this increase in time was proportionately greater for the SITA algorithms than for the Full Threshold and FASTPAC algorithms ($P < 0.001$), particularly that of SITA Fast (Table 2). The group mean examination duration also varied as a function-of-order of test ($P < 0.001$), and this order effect was different between tests ($P < 0.001$). The subgroup mean examination time for the Full Threshold algorithm and for the SITA Standard algorithm was longer when the algorithms were undertaken as the second test at any given session, whereas that for the FASTPAC algorithm was shorter as the second test of any session.

**Pointwise Differences in Sensitivity**

The 10th, 50th, and 90th percentiles of the distribution of the within-visit between-algorithm difference in sensitivity at each sensitivity level of all the four algorithms were illustrated in Figure 1. The 50th percentile of the differences between the Full Threshold and FASTPAC algorithms approximated to zero for sensitivities between 35 dB and 20 dB after which the value became more variable. The 10th and 90th percentiles increased as sensitivity decreased; in the case of the 90th percentile, the magnitude peaked at a sensitivity of approximately 14 dB, after which it declined. The 50th percentiles of the differences between the Full Threshold and each of the SITA Standard and SITA Fast algorithms exhibited a negative value (indicating a higher sensitivity for SITA), which became more negative as sensitivity decreased from 34 dB to approximately 12 dB, after which the magnitudes became more variable but then tended to converge toward zero. The 50th percentile was more negative between Full Threshold and SITA Fast than between Full Threshold and SITA Standard. The 10th and 90th percentiles of the differences also increased as sensitivity decreased. The 90th percentile for both distributions was largest at a sensitivity of approximately 15 dB, after which it declined; the 10th percentile continuously increased for both distributions up to a sensitivity of approximately 4 dB. A similar trend was present between the FASTPAC and the SITA Standard and the SITA Fast algorithms. The 50th percentiles were both negative and were more negative for the SITA Fast algorithm (indicating that the SITA Fast algorithm yielded a higher sensitivity).

The 10th, 50th, and 90th percentiles of the distribution of the within-algorithm between-visit difference in sensitivity at each sensitivity level for the four algorithms between visits two and three are illustrated in Figure 2. The extent of the distributions of the within-algorithm between-visit differences in sensitivity were similar to the between-algorithm within-visit differences in sensitivity.

**Pointwise Differences in the Total and the Pattern Deviation Probability Values**

The pointwise within-visit between-algorithm differences in the Total Deviation and in the Pattern Deviation probability values between each of the four algorithms at the second visit for all 29 individuals are given in Tables 3 and 4. The differences in the Total Deviation probability values between the Full Threshold and FASTPAC algorithms and between the SITA Standard and SITA Fast algorithms did not reach statistical significance ($P = 0.975$ and $P = 0.067$, respectively). A more significant Total Deviation probability value (i.e., a more statistically significant defect depth) was found for the SITA Standard algorithm compared to the Full Threshold and to the FASTPAC algorithms (both $P < 0.001$) and for the SITA FAST compared to the Full Threshold and FASTPAC algorithms (both $P < 0.001$). The differences in the Pattern Deviation probability values between the Full Threshold and FASTPAC algorithms and between the SITA Standard and SITA Fast algorithms also did not reach statistical significance ($P = 0.857$ and $P = 0.083$ respectively). A more significant Pattern Deviation probability value was found for the SITA Standard algorithm compared to the Full Threshold and to the FASTPAC algorithms (both $P < 0.001$) and for the SITA FAST compared to the Full Threshold and FASTPAC algorithms (both $P < 0.001$). The pointwise between-visit within-algorithm differences in the Total Deviation and in the Pattern Deviation probability values for each of the four algorithms between the second and third visits are given in Tables 5 and 6. The differences in the

**TABLE 2.** Group Mean Examination Duration for the Full Threshold, FASTPAC, SITA Standard, and SITA Fast Algorithms as a function of Severity of Field Loss

<table>
<thead>
<tr>
<th>Severity</th>
<th>Full Threshold</th>
<th>FASTPAC</th>
<th>SITA Standard</th>
<th>SITA Fast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>14.11 ± 1.17</td>
<td>8.60 ± 0.90</td>
<td>7.28 ± 0.58</td>
<td>4.15 ± 0.47</td>
</tr>
<tr>
<td>Moderate</td>
<td>16.09 ± 1.45</td>
<td>9.87 ± 0.83</td>
<td>7.97 ± 0.81</td>
<td>4.67 ± 0.45</td>
</tr>
<tr>
<td>Severe</td>
<td>15.46 ± 1.45</td>
<td>10.78 ± 1.29</td>
<td>8.93 ± 0.99</td>
<td>5.87 ± 0.67</td>
</tr>
</tbody>
</table>

Values are the group means ± 1 SD, expressed as minutes.
distributions of the Total Deviation probability values between the two visits were not statistically significant for all four algorithms (Full Threshold, $P = 0.164$; FASTPAC, $P = 0.859$; SITA Standard, $P = 0.401$; SITA Fast, $P = 0.106$). The differences in the distributions of the Pattern Deviation probability values between the two visits were not statistically significant for three of the four algorithms (Full Threshold, $P = 0.427$; SITA Standard, $P = 0.972$; SITA Fast, $P = 0.286$). However, FASTPAC exhibited a more statistically significant Pattern Deviation defect at the second visit than at the third visit ($P = 0.006$). The proportion of stimulus locations exhibiting deviations within the 95% confidence limits at both visits for the given algorithm declined in rank order from the Full Threshold to FASTPAC, SITA Standard, and SITA Fast for both the Total Deviation and the Pattern Deviation probability values. The proportion of such locations was greater for the Pattern than for the Total Deviation probability values. When those locations exhibiting between-visit deviations within the 95% confidence limits were excluded from the Total and the Pattern Deviation analyses, the similarity of the between-visit variability between the Full Threshold and SITA Standard and between FASTPAC and SITA Fast, respectively, was more pronounced for both the Total and the Pattern Deviation analyses. However, in proportionate terms, the FASTPAC algorithm yielded

![Figure 1](https://example.com/figure1.png)

**Figure 1.** The 10th, 50th, and 90th percentiles of the distribution of the differences in sensitivity across all locations between each pair of algorithms at the second visit as a function of the sensitivity of the reference algorithm at the given location at the second visit (i.e., the within-visit between-algorithm evaluation).
the greatest test-retest variability for both the Total and the Pattern Deviation probability analyses.

**DISCUSSION**

The validity of the sample as representative of the glaucomatous population was confirmed by the difference in the group mean MD, the group mean CPSD, the group mean examination duration, and the group mean Short-term Fluctuation between the Full Threshold and the FASTPAC algorithms. The approximate 36% reduction in the examination duration and the approximate 15% increase in the Short-term Fluctuation is comparable with that reported previously for the glaucomatous visual field.4–7

The SITA algorithms yield slightly higher values of MS than the Full Threshold and FASTPAC algorithms. The group mean MS for SITA Standard was 1.0 dB higher than for Full Threshold and 1.6 dB higher for SITA Fast than FASTPAC. These results compare favorably with the corresponding differences found in the normal eye of 0.8 and 1.3 dB, respectively.11 Although the differences in MSs are statistically significant, they become clinically insignificant in the context of the statistically identical MDs, which describe alterations in the height of the hill of vision relative to the respective age corrected normal values of each algorithm. The SITA Standard algorithm yielded a marginally higher group mean PSD than the Full Threshold and FASTPAC algorithms, indicating a slightly greater defect depth for SITA Standard. The suggestion of a greater defect with the SITA Standard algorithm became more apparent as defect depth increased. The differences in the PSDs between the algorithms, although reaching statistical significance, were relatively unimportant clinically. Furthermore, the indices themselves are of limited clinical value in the detection of progressive visual field loss as they are merely summary measures of the sensitivities at all stimulus locations.16

The subgroup mean MS was lower, the subgroup mean MD more negative, and the subgroup mean examination duration longer for both the Full Threshold and the SITA Standard algorithms when the particular algorithm was undertaken as the second test at any given session. A similar finding for MD has previously been reported in a two-period crossover trial between the Full Threshold and FASTPAC algorithms. This finding was attributed to an increased fatigue effect operative when the longer Full Threshold strategy was performed second, rather than to any systematic difference between algorithms.4

The purpose of the within-visit between-algorithm and the within-algorithm between-visit pointwise analyses was to determine the within-individual differences in the absolute value of sensitivity at each stimulus location, not the difference in pointwise deviations from each respective normal database. The results of the within-visit between-algorithm pointwise analysis indicate that the SITA algorithms exhibit a slightly higher absolute value of pointwise sensitivity, that this differ-

**FIGURE 2.** The 10th, 50th, and 90th percentiles of the distribution of the differences in sensitivity across all locations between the given algorithm at the second and third visit as a function of the sensitivity of the reference algorithm at the given location at the second visit (i.e., the within-algorithm between-visit evaluation).
Table 3. The within-individual within-visit between-algorithm difference in the number of probability values for the Total Deviation Probability Analysis at each stimulus location across all 29 patients for each of the between-algorithm comparisons.

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<tr>
<th></th>
<th>FASTPAC</th>
<th>SITA Standard</th>
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<tr>
<td></td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
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<td>Full Threshold</td>
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<tr>
<td>NS</td>
<td>1279 117 35 13 15</td>
<td>NS 1148 151 71 38 40</td>
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<td>&lt;5%</td>
<td>89 56 13 14 12</td>
<td>&lt;5% 87 44 39 22 24</td>
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<td>24 9 10 19 23</td>
<td>&lt;1% 5 16 6 10 44</td>
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<td>&lt;0.5%</td>
<td>21 12 14 23 227</td>
<td>&lt;0.5% 12 14 10 17 247</td>
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<th>SITA Fast</th>
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<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
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<tr>
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<td>NS</td>
<td>1173 152 78 30 26</td>
<td>NS 1133 148 82 55 30</td>
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<td>&lt;5%</td>
<td>59 48 31 22 24</td>
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<td>&lt;1%</td>
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<td>&lt;1% 15 6 11 15 34</td>
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<td>&lt;5% 104 54 46 25 14</td>
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<td>&lt;2%</td>
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<th></th>
<th>FT-FP</th>
<th>FT-SS</th>
<th>FT-SF</th>
<th>FP-SS</th>
<th>FP-SF</th>
<th>SS-SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>More statistically significant defect with 1st algorithm (%)</td>
<td>12.1</td>
<td>7.8</td>
<td>10.4</td>
<td>9.6</td>
<td>12.4</td>
<td>17.6</td>
</tr>
<tr>
<td>Identical with 1st and 2nd algorithms (%)</td>
<td>75.0</td>
<td>70.5</td>
<td>68.5</td>
<td>68.0</td>
<td>65.8</td>
<td>66.5</td>
</tr>
<tr>
<td>More statistically significant defect with 2nd algorithm (%)</td>
<td>12.9</td>
<td>21.7</td>
<td>21.0</td>
<td>22.3</td>
<td>21.7</td>
<td>15.9</td>
</tr>
</tbody>
</table>

*Top left:* Full Threshold compared to FASTPAC; *middle left:* Full Threshold compared to SITA Standard; *bottom left:* Full Threshold compared to SITA Fast; *top right:* FASTPAC compared to SITA Standard; *middle right:* FASTPAC compared to SITA Fast; *bottom right:* SITA Standard compared to SITA Fast. The data are expressed as a percentage in the summary table at the bottom.
Table 4. The within-individual within-visit between-algorithm difference in the number of probability values for the Pattern Deviation Probability Analysis at each stimulus location across all 29 patients for each of the between-algorithm comparisons.

<table>
<thead>
<tr>
<th></th>
<th>FASTPAC</th>
<th>SITA Standard</th>
<th>SITA Fast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
</tr>
<tr>
<td>Full Threshold</td>
<td>NS</td>
<td>&lt;5%</td>
<td>&lt;2%</td>
</tr>
<tr>
<td></td>
<td>1486</td>
<td>69</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>&lt;5%</td>
<td>52</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>&lt;2%</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>&lt;1%</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>&lt;0.5%</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>SITA Standard</td>
<td>NS</td>
<td>&lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
</tr>
<tr>
<td>Full Threshold</td>
<td>NS</td>
<td>1412</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>&lt;5%</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>&lt;2%</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>&lt;1%</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>&lt;0.5%</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>SITA Fast</td>
<td>NS</td>
<td>&lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
</tr>
<tr>
<td>Full Threshold</td>
<td>NS</td>
<td>1398</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>&lt;5%</td>
<td>45</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>&lt;2%</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>&lt;1%</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>&lt;0.5%</td>
<td>23</td>
<td>10</td>
</tr>
</tbody>
</table>

More statistically significant defect with 1st algorithm (%)

<table>
<thead>
<tr>
<th></th>
<th>FT-FP</th>
<th>FT-SS</th>
<th>FT-SF</th>
<th>FP-SS</th>
<th>FP-SF</th>
<th>SS-SF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.9</td>
<td>6.3</td>
<td>8.5</td>
<td>7.3</td>
<td>9.2</td>
<td>13.3</td>
</tr>
<tr>
<td>Identical with 1st and 2nd algorithms (%)</td>
<td>81.4</td>
<td>78.4</td>
<td>76.0</td>
<td>77.4</td>
<td>75.3</td>
<td>74.7</td>
</tr>
<tr>
<td>More statistically significant defect with 2nd algorithm (%)</td>
<td>9.7</td>
<td>15.2</td>
<td>15.4</td>
<td>15.3</td>
<td>15.5</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Top left: Full Threshold compared to FASTPAC; middle left: Full Threshold compared to SITA Standard; bottom left: Full Threshold compared to SITA Fast; top right: FASTPAC compared to SITA Standard; middle right: FASTPAC compared to SITA Fast; bottom right: SITA Standard compared to SITA Fast. The data are expressed as a percentage in the summary table at the bottom.
TABLE 5. The within-individual within-algorithm between-visit difference in the number of probability values for the Total Deviation Probability Analysis at each stimulus location across all 29 patients for each of the four algorithms.

<table>
<thead>
<tr>
<th></th>
<th>Full Threshold Visit 3</th>
<th>FASTPAC Visit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
</tr>
<tr>
<td>Full Threshold Visit 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS</td>
<td>1329 79 23 11 17</td>
<td>1252 110 51 17 18</td>
</tr>
<tr>
<td>&lt;5%</td>
<td>102   61 10 8 3</td>
<td>&lt;5% 131 36 24 8 17</td>
</tr>
<tr>
<td>&lt;2%</td>
<td>37    19 31 9 25</td>
<td>&lt;2% 37 11 24 11 18</td>
</tr>
<tr>
<td>&lt;1%</td>
<td>21    11 10 21 22</td>
<td>&lt;1% 16 11 7 24 23</td>
</tr>
<tr>
<td>&lt;0.5%</td>
<td>7     11 12 14 253</td>
<td>&lt;0.5% 25 17 17 19 222</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SITA Standard Visit 3</th>
<th>SITA Fast Visit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
<td>NS &lt;5% &lt;2% &lt;1% &lt;0.5%</td>
</tr>
<tr>
<td>SITA Standard Visit 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS</td>
<td>1125 88 27 18 16</td>
<td>1089 117 39 29 11</td>
</tr>
<tr>
<td>&lt;5%</td>
<td>91    66 42 27 17</td>
<td>&lt;5% 117 57 25 20 12</td>
</tr>
<tr>
<td>&lt;2%</td>
<td>40    30 29 24 14</td>
<td>&lt;2% 57 40 19 22 16</td>
</tr>
<tr>
<td>&lt;1%</td>
<td>15    16 19 22 30</td>
<td>&lt;1% 30 26 23 46 33</td>
</tr>
<tr>
<td>&lt;0.5%</td>
<td>15    12 15 26 322</td>
<td>&lt;0.5% 9 16 11 42 240</td>
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</tbody>
</table>

Including repeated NS locations

<table>
<thead>
<tr>
<th></th>
<th>FT</th>
<th>FP</th>
<th>SS</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>More statistically significant defect at Visit 2 (%)</td>
<td>11.4</td>
<td>13.6</td>
<td>13.0</td>
<td>17.3</td>
</tr>
<tr>
<td>Identical at 1st and 2nd Visits (%)</td>
<td>79.0</td>
<td>72.6</td>
<td>72.9</td>
<td>67.6</td>
</tr>
<tr>
<td>More statistically significant defect at Visit 3 (%)</td>
<td>9.6</td>
<td>13.8</td>
<td>14.1</td>
<td>15.1</td>
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</tbody>
</table>

NOT including repeated NS locations

<table>
<thead>
<tr>
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<th>FT</th>
<th>FP</th>
<th>SS</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>More statistically significant defect at Visit 2 (%)</td>
<td>29.9</td>
<td>32.6</td>
<td>27.3</td>
<td>35.1</td>
</tr>
<tr>
<td>Identical at 1st and 2nd Visits (%)</td>
<td>44.8</td>
<td>34.2</td>
<td>43.0</td>
<td>34.2</td>
</tr>
<tr>
<td>More statistically significant defect at Visit 3 (%)</td>
<td>25.3</td>
<td>33.2</td>
<td>29.7</td>
<td>30.7</td>
</tr>
</tbody>
</table>

Top left: Full Threshold; bottom left: SITA Standard; top right: FASTPAC; bottom right: to SITA Fast. The data are expressed as a percentage in the summary table at the bottom.
Table 6. The within-individual within-algorithm between-visit difference in the number of probability values for the Pattern Deviation Probability Analysis at each stimulus location across all 29 patients for each of the four algorithms.

<table>
<thead>
<tr>
<th>Top left: Full Threshold Visit 3</th>
<th>NS</th>
<th>&lt;5%</th>
<th>&lt;2%</th>
<th>&lt;1%</th>
<th>&lt;0.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>1519</td>
<td>49</td>
<td>17</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>&lt;5%</td>
<td>56</td>
<td>16</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>&lt;2%</td>
<td>32</td>
<td>10</td>
<td>26</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>&lt;1%</td>
<td>12</td>
<td>12</td>
<td>5</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>&lt;0.5%</td>
<td>9</td>
<td>10</td>
<td>5</td>
<td>14</td>
<td>230</td>
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<table>
<thead>
<tr>
<th>FASTPAC Visit 2</th>
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<th>&lt;2%</th>
<th>&lt;1%</th>
<th>&lt;0.5%</th>
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</thead>
<tbody>
<tr>
<td>NS</td>
<td>1477</td>
<td>70</td>
<td>27</td>
<td>15</td>
<td>16</td>
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<tr>
<td>&lt;5%</td>
<td>67</td>
<td>14</td>
<td>17</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>&lt;2%</td>
<td>42</td>
<td>12</td>
<td>21</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>&lt;1%</td>
<td>18</td>
<td>8</td>
<td>7</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>&lt;0.5%</td>
<td>28</td>
<td>24</td>
<td>10</td>
<td>17</td>
<td>191</td>
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</table>

<table>
<thead>
<tr>
<th>SITA Standard Visit 3</th>
<th>NS</th>
<th>&lt;5%</th>
<th>&lt;2%</th>
<th>&lt;1%</th>
<th>&lt;0.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>1366</td>
<td>68</td>
<td>28</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>&lt;5%</td>
<td>79</td>
<td>29</td>
<td>23</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>&lt;2%</td>
<td>25</td>
<td>16</td>
<td>13</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>&lt;1%</td>
<td>17</td>
<td>2</td>
<td>11</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>&lt;0.5%</td>
<td>24</td>
<td>16</td>
<td>7</td>
<td>18</td>
<td>288</td>
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</table>

<table>
<thead>
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<th>SITA Fast Visit 3</th>
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<th>&lt;2%</th>
<th>&lt;1%</th>
<th>&lt;0.5%</th>
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<tbody>
<tr>
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<td>1334</td>
<td>81</td>
<td>39</td>
<td>30</td>
<td>22</td>
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<tr>
<td>&lt;5%</td>
<td>67</td>
<td>25</td>
<td>17</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>&lt;2%</td>
<td>30</td>
<td>15</td>
<td>11</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>&lt;1%</td>
<td>20</td>
<td>11</td>
<td>12</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>&lt;0.5%</td>
<td>25</td>
<td>13</td>
<td>15</td>
<td>24</td>
<td>228</td>
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</table>

<table>
<thead>
<tr>
<th>Including repeated NS locations</th>
<th>FT</th>
<th>FP</th>
<th>SS</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>More statistically significant defect at Visit 2 (%)</td>
<td>7.7</td>
<td>10.9</td>
<td>10.0</td>
<td>11.7</td>
</tr>
<tr>
<td>Identical at 1st and 2nd Visits (%)</td>
<td>84.1</td>
<td>80.2</td>
<td>79.8</td>
<td>75.7</td>
</tr>
<tr>
<td>More statistically significant defect at Visit 3 (%)</td>
<td>8.2</td>
<td>8.9</td>
<td>10.2</td>
<td>12.6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>NOT including repeated NS locations</th>
<th>FT</th>
<th>FP</th>
<th>SS</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>More statistically significant defect at Visit 2 (%)</td>
<td>26.32</td>
<td>34.83</td>
<td>27.56</td>
<td>31.03</td>
</tr>
<tr>
<td>Identical at 1st and 2nd Visits (%)</td>
<td>45.61</td>
<td>36.47</td>
<td>44.36</td>
<td>35.71</td>
</tr>
<tr>
<td>More statistically significant defect at Visit 3 (%)</td>
<td>28.07</td>
<td>28.70</td>
<td>28.08</td>
<td>33.25</td>
</tr>
</tbody>
</table>

*Top left: Full Threshold; bottom left: SITA Standard; top right: FASTPAC; bottom right: to SITA Fast. The data are expressed as a percentage in the summary table at the bottom.*
ence increases as sensitivity declines, and that the difference is
greatest for SITA Fast. The finding of a slightly higher sensitivity
for the SITA algorithms is of limited clinical value because the
statistical definition of abnormality is dependent on the estab-
lishment of age-corrected confidence limits for normality at
each location which, in turn, are based on the normal database
specific to each algorithm. The differences in the magnitude of
the confidence limits between algorithms is the crucial issue.11

The increased spread of the 10th and 90th percentiles of the
distributions of the within-visit between-algorithm and of the
within-algorithm between-visit differences in sensitivity
between approximately 20 and 10 dB are caused by the inher-
ent increased variability displayed at this level of sensitivity,17
which is present at both examinations. The irregularity of the
increased spread of these percentiles can be attributed, in part,
to the lower number of data points within the midsensitivity
levels. The greater divergence of the 10th percentile for sen-
sitivities of less than 10 dB compared to the 90th percentile is
the mathematical consequence of a high value at the second
test being subtracted from, and referenced to, a low value with
large variability at the first test, hence biasing the differences
toward negative values.

The pointwise analyses of differences in absolute sensitiv-
ity did not take into account the between-individual differ-
ences in sensitivity due to age and the within- and between-
individual differences at any given stimulus location due to the
covariance of sensitivity with increase in eccentricity and with
defect depth. The age of the sample ranged from 42 to 72 years
with a mean of 67 years. The age decline in sensitivity of the
normal eye, based on cross-sectional data, varies between stim-
ulus locations but is approximately 0.7 dB per decade.11,18
Thus, the maximum between-individual discrepancy at any
given stimulus location due to age would be in the region of
2.1 dB, i.e., generally within one interval of the scale on the
abscissa of Figure 2. The magnitude of the normal gradient of
sensitivity across the Program 30-2 field varies with region, has
an upper limit of approximately 9 dB,18 and governs the max-
imum within- and between-individual discrepancy between a
normal peripheral value and an abnormal central value. The
impact of age on the pointwise between-individual differences
in sensitivity could have been reduced by considering the
between-algorithm difference in sensitivity at the given stimu-
lus location as a function of the deviation of measured sensi-
tivity of the reference algorithm from the age-corrected normal
value. Such an approach was adopted by Heijl and colleagues17
but does not distinguish normal reductions in sensitivity due to
eccentricity from identical but abnormal values due to a defect.
Moreover, such a technique would reduce the impact of any
between-algorithm comparison of absolute values of sensitivity
since the generated deviation values would be derived from
each individual normal database. A comparison of the distribu-
tions of the within-visit between-algorithm and of the within-
algorithm between-visit differences in sensitivity as a function
of central and peripheral stimulus location yielded similar dis-
butions between the two zones indicating that any potential
differences due to stimulus eccentricity were masked by the
underlying field loss. However, the analysis of the pointwise
Total and Pattern Deviation probability values overcomes any
limitations in the comparison of the absolute values of sensi-
tivity, because the respective confidence limits are corrected
for both age and eccentricity.

The Total Deviation probability analysis identifies devia-
tions in the height of the visual field from the age-matched
normal sensitivity (i.e., generalized or diffuse loss). The Pattern
Deviation probability analysis identifies deviations in the shape
of the field (i.e., focal loss) once the height of the field has been
corrected to the level of the normal reference field. Analysis of
both the Total and the Pattern Deviation probability values was
undertaken for several reasons. First, the prediction limits for
normality at any given location are different between the Total
Deviation and Pattern Deviation probability analyses. Second, it
is equivocal as to whether the earliest sign of glaucomatous
visual field loss is diffuse or focal damage.19,20 The height
adjustment of the Pattern Deviation approach also served to
reduce any experimental error that might have affected the
overall height of any given single field of any given patient, e.g.,
that arising from an increased homogeneous long-term fluctu-
ation. Conversely, the Total Deviation approach is unaffected
by any inappropriate readjustment in height.

The results of the analysis of the Total and Pattern Devia-
tion probability values are consistent with the report of a
narrower pointwise between-subject variation in normal sen-
sitivity for the SITA Standard and the SITA Fast algorithms
when compared to the Full Threshold and FASTPAC algorithms.11
It must be noted that such analysis is based on differences in
probability values and not differences in deviation values. The
results also confirm the suggestion that the narrower confi-
dence limits for the SITA algorithms correspond to lighter
levels of gray in the greyscale printout than those for the Full
Threshold algorithm, particularly for the proportionately larger
deviations from normality and that the widths of the confi-
dence limits for SITA are such that multiple changes in prob-
ability level can occur within a given level of gray.11

The results of the Total and Pattern Deviation probability
analyses also confirm that the long-term follow-up of glauco-
matus patients with the Full Threshold algorithm can, in
general, be safely continued using the SITA Standard algorithm.
However, it can be conjectured that those patients particularly
prone to the fatigue effect with the Full Threshold algorithm
might, when first examined with the shorter SITA algorithms,
exhibit less severe field loss compared to the immediate pre-
vious examination undertaken with the Full Threshold algo-
rithm. The fatigue effect is most apparent at stimulus locations
that exhibit relative loss, and it increases with the duration of
the examination, varies in magnitude between individuals, and
leads to an overestimation of the defect depth.21–24 A reduc-
tion in the fatigue effect has been suggested as a possible
explanation for the reduced between-subject normal variability
of the SITA algorithms compared to the Full Threshold and
FASTPAC algorithms. However, the nature of any between-
algorithm differences in the fatigue effect is unknown. It is also
likely that the statistically deeper defect depth of the SITA
algorithms will largely mitigate against any apparent improve-
ment of the SITA field in these patients. Alternatively, some
patients who do not manifest a fatigue effect with the Full
Threshold algorithm may exhibit fields that are worse with
SITA Standard as a result of the statistically deeper SITA defect
depth. These potential problems could be resolved at the
designated follow-up by undertaking a Full Threshold exami-
nation followed, within a short time frame, by two SITA exami-
nations. In this way, the SITA baseline for successive exami-
nations would have been established.
The profound reduction in the examination time of the SITA algorithms, together with the capability to detect a statistically deeper defect depth offers an opportunity for a revision of the role of the visual field examination in glaucoma practice. The reduced examination time compared to both the Full Threshold and FASTPAC algorithms dictates either that a given patient can undergo a visual field examination more frequently or that more patients can be seen per unit time. The opportunity for a more frequent re-examination of the same patient provides greater scope for the recognition of progressive visual field loss in that the natural history of the disease process can be followed more regularly and that the adverse statistical impact of the long-term fluctuation can be reduced by more frequent examinations. The utility of the SITA algorithms is also such that should either an apparent visual field abnormality be detected for the first time or an apparent progression of an existing abnormality be identified, then the findings can be immediately verified by the use of a repeat SITA examination without causing a significant loss of clinical time.

The SITA algorithms produce marginally higher Group mean MSs and pointwise sensitivities compared to the existing Full Threshold and FASTPAC algorithms. However, both SITA algorithms describe a more statistically significant defect depth together with a halving of the examination duration for SITA Standard compared to the Full Threshold algorithm and for SITA Fast compared to FASTPAC. The narrower confidence limits, a similar between-visit variability combined with a marked reduced examination duration compared to the existing “gold standard” perimetric threshold algorithms, ensure that the SITA algorithms will generate a quantum leap for the role of the visual field examination in the detection and management of POAG.

References