

New developments for automated visual field testing.

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Over the past 25 to 30 years, perimetry and visual field testing have undergone dramatic improvements, including the advent of automated testing procedures, the development of efficient and accurate testing strategies, an evaluation of new testing procedures, and the derivation of new data analysis methods. This article briefly describes some of the most recent innovations that have emerged for automated perimetry. Although this article's title refers to software upgrades for automated perimetry, it should be noted that some of these enhancements have also resulted in hardware modifications. Thus, the more general term *upgrades for automated perimetry* may be more appropriate.

NEW PERIMETRIC TEST STRATEGIES

SITA

The Swedish Interactive Threshold Algorithm (SITA) is a forecasting procedure for obtaining visual field threshold estimates according to Bayesian statistical principles.¹ Two procedures are available: SITA-Standard and SITA-Fast.¹⁻⁴ The former is the most commonly used procedure. SITA-Fast was designed to reduce test time further, but at the expense of greater variability. A number of investigations have evaluated the properties of SITA-Standard, and, except for a few minor differences,⁴ this procedure is equal to or slightly better than other threshold estimation procedures with regard to its sensitivity, specificity, characterization, and reliability of determining visual field properties.¹⁻³ Figure 1 presents an example of the printed output for SITA-Standard. Because of their significant time advantages, the SITA methods have now become standard threshold estimation procedures for automated perimetry in most clinical settings.

ZEST

The Zippy Estimation of Sequential Thresholds (ZEST) is a Bayesian forecasting procedure similar to SITA that has been implemented on the new Humphrey Matrix

perimeter (Carl Zeiss Meditec Inc., Dublin, CA), which uses Frequency Doubling Technology (FDT; Welch Allyn Medical Products, Skaneateles, NY).⁵ ZEST has been reported to demonstrate sensitivity, specificity, and reproducibility that is comparable to other threshold estimation procedures, while reducing test time by approximately 50%.⁶ The FDT version of ZEST appears to have some advantages over the SITA procedure: (1) ZEST is computationally and procedurally simpler than SITA, and

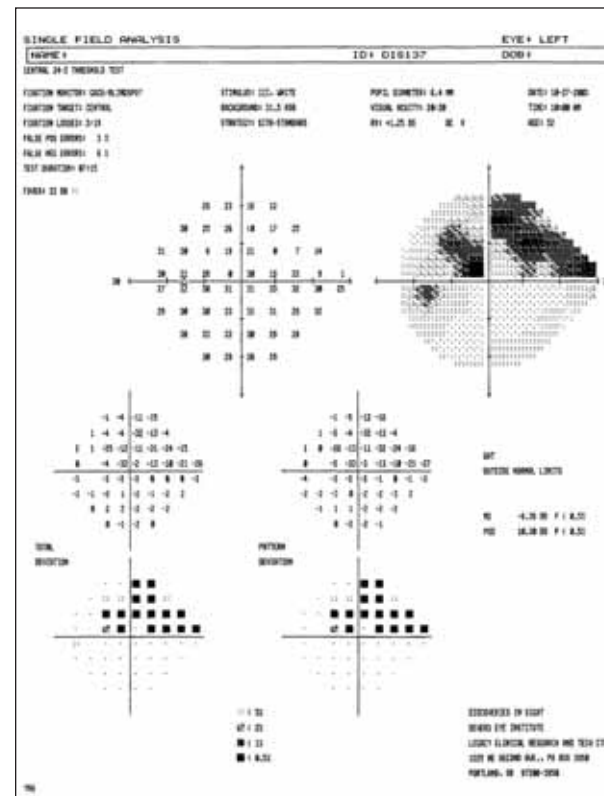


Figure 1. The Humphrey Field Analyzer SITA-Standard test yielded these results for the left eye of a patient with glaucomatous damage and a superior arcuate nerve fiber bundle defect.

available on the Octopus perimeter (INTERZEAG, Berne, Switzerland) that uses linear interpolation and evaluation of adjacent locations to produce a rapid estimation of visual field sensitivity.^{8,9} Recent investigations report that TOP is able to perform accurate threshold determinations at a significantly reduced testing time.^{8,9} Investigators have also shown, however, that the test procedure employed by TOP produces an underestimation of sensitivity for small visual field deficits (one or two stimulus locations) and decreases the slope of the boundary around visual field deficits.¹⁰

NEW PERIMETRIC TEST PROCEDURES

SITA SWAP

Short Wavelength Automated Perimetry (SWAP) was introduced as a clinical diagnostic test more than 15 years ago. SWAP uses a bright (315 apostilb or 100 cd/m²) yellow background and a large (Goldmann size V), narrow-bandwidth, blue stimulus to isolate and measure the sensitivity of short wavelength (S-cone) mechanisms by means of test procedures that are highly similar to those employed by standard automated perimetry (white stimulus on a white background). Optimal parameters for SWAP testing have been derived, and longitudinal studies have confirmed that SWAP (1) detects nerve fiber layer-type deficits in glaucoma, (2) is predictive of future glaucomatous visual field loss for standard automated perimetry, (3) demonstrates a greater rate of progressive glaucomatous visual field loss than does standard automated perimetry, and (4) correlates with other clinical factors associated with glaucoma.¹¹⁻¹⁵ In addition, SWAP has been shown to be effective in the detection of visual field loss produced by other ocular and neurologic disorders.¹⁶

One disadvantage of SWAP is the large amount of time required to perform the test. The SITA test procedure, however, has recently been utilized for SWAP testing, with generally positive clinical results. SITA SWAP has several advantages, including significantly reduced test time (3 to 4 minutes per eye vs 15 to 18 minutes per eye), an expanded dynamic test range (3 to 4 dB), slightly reduced variability, and a sensitivity and specificity that is comparable to the Full Threshold SWAP test. Several investigations have now described results using the SITA SWAP test procedure.^{17,18}

Humphrey Matrix FDT

When a low spatial frequency, sinusoidal grating (large dark and light stripes) undergoes high temporal frequen-



Figure 2. The Humphrey Matrix perimeter with FDT.

cy, counterphase flicker (rapid light/dark stripe alternation), there appear to be twice as many light and dark bars (the frequency doubling effect). A clinical test device that incorporates FDT has been effective in detecting visual field loss in glaucoma and other ocular and neurologic disorders (summarized in Anderson and Johnson¹⁹). The procedure involves measuring contrast-detection thresholds for the FDT stimulus at key visual field locations. More than 10,000 FDT devices are in use throughout the world.

A recently developed second generation of FDT devices, known as the Humphrey Matrix, is currently undergoing clinical validation. The Humphrey Matrix utilizes the frequency doubling effect and incorporates all of the tests available for the original FDT instrument. In addition, the device uses a larger number of small targets to produce several new stimulus patterns (24-2, 30-2, 10-2, and macula tests), and it employs a smart threshold-forecasting strategy known as ZEST (see earlier description) that is similar to SITA.^{5,6} Preliminary clinical evaluations indicate that the Humphrey Matrix is effective in detecting visual field loss from glaucoma and other disorders (Figures 2 and 3).

NEW DATA ANALYSIS PROCEDURES

GPA

The determination of visual field progression in glaucoma remains an important and perplexing problem.²⁰ The Glaucoma Change Probability (GCP) analysis procedure for the Humphrey Field Analyzer (Carl Zeiss Meditec Inc.) provides a means of longitudinally evaluating glaucomatous visual fields. The GCP was not designed to be used for SITA visual field tests, however.

Recently, the Glaucoma Progression Analysis (GPA)

glaucoma patients. The GPA program also has several additional advantages, however. First, the GPA procedure is designed to analyze SITA visual fields. Second, practitioners may use either Full Threshold or SITA results for baseline determinations. Third, visual field locations that are outside the expected variability characteristics on two and three successive follow-up visual fields are respectively denoted by special symbols. Fourth, if three or more locations are outside the expected variability characteristics on two successive follow-up visual fields, the system applies the designation of *possible progression*. If three or more locations are outside the expected variability characteristics on three successive follow-up visual fields, the system applies the designation of *likely progression*. All of these improvements provide a useful means of monitoring a patient's glaucomatous visual field status over time.

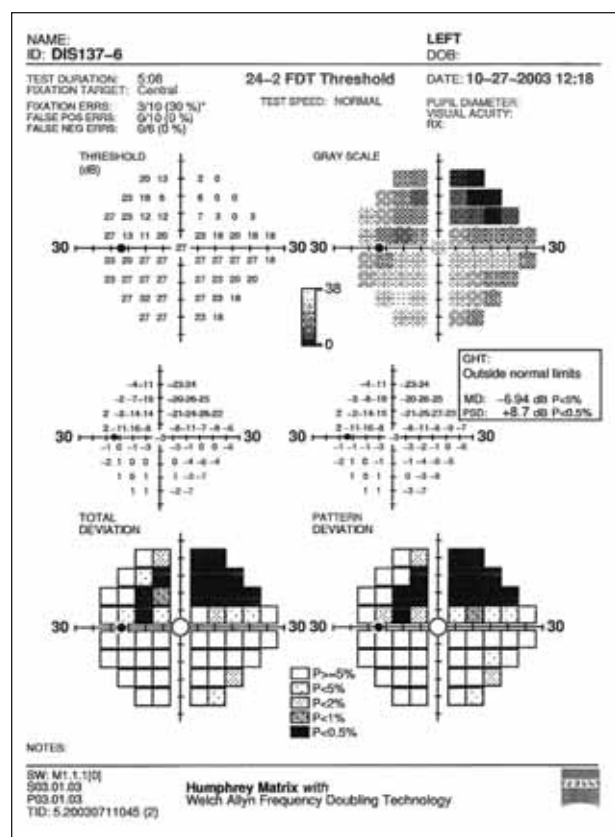


Figure 3. Using the 24-2 test presentation pattern, the Humphrey Matrix yielded these results for the left eye of the same patient whose results appear in Figure 1.

of detecting glaucomatous pathology, accurately monitor progressive changes, and combine the structural and functional consequences of damage will further enhance these testing procedures. □

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