Dr Robert Cubbidge looks at the analysis of the various data produced by modern fields machines. Module C19275, one general CET point for optometrists and dispensing opticians.

Analysis of suprathreshold static perimetry

The visual field plot from suprathreshold perimetry usually consists of a series of dots or circles indicating the stimulus locations tested during the visual field examination and a numerical value showing the threshold level of the patient from which the suprathreshold level was set. Dots or open circles indicate that the patient observed the suprathreshold stimulus, whereas a closed circle indicates that the patient was unable to detect the stimulus. Some perimeters quantify the visual field loss by assessing its depth using brighter stimuli. The depth of the scotoma may therefore be identified by a decibel value or a greyscale symbol.

When single stimulus suprathreshold is carried out, the perimeter also makes measures of fixation losses, false negative and positive responses which give the examiner an indication of the reliability of the results.

Analysis of full threshold static perimetry

The advantage of full threshold automated static perimetry over suprathreshold static perimetry is the greater information it yields about the threshold across the visual field which enables comparison of measured data with age-matched normal data contained within the perimeter software. A number of sophisticated software packages exist to aid the practitioner in the evaluation of the final visual field outcome; each specific for a given perimeter manufacturer, the commonest being Field View (Dicon), Statpac (Humphrey) and Peri-Trend (Octopus). Basic analysis software is also contained in the Henson perimeters for full threshold evaluation. Data analysis is only possible for stimulus and grid configurations where the perimeter has age-matched normal data. It should be remembered that although these software packages provide diagnostic information, they should be considered as an aid to diagnosis, requiring clinical evaluation and decision making by the practitioner. Visual field data is provided for evaluation in a variety of ways, either by a printout or electronically via a personal computer.

Figure 1 Greyscale plot (upper right) appears normal despite some inferior loss

Figure 2 Greyscale showing extensive superior loss

**Numeric data**

The simplest form of data presentation is a representation of threshold values in decibels arranged in the spatial locations of the test grid. Some threshold algorithms estimate the threshold twice at specific locations in the visual field. When the threshold has been determined twice it is termed a double determination. They are illustrated on the numeric printout by the two values of sensitivity (the second determination in brackets). The numeric printout permits the display of the raw data prior to statistical manipulation. High numbers represent regions of high light sensitivity in the visual field. In a normal visual field, the inferior visual field generally exhibits slightly higher sensitivity than the superior visual field. Sensitivities are greatest in the central visual field and exhibit a gradual decline towards the visual field periphery, reflecting the shape of the hill of vision. A decibel value of 0dB indicates detection of the brightest light stimulus the perimeter is able to generate. A value of < 0dB indicates that the patient was unable to detect the maximum stimulus luminance (differing between perimeters but typically in the order of 10,000asb), but this does not necessarily mean that the patient has no light perception in that region of the visual field. Although the numeric printout gives the practitioner some indication of areas of defect in the visual field, the large amounts of such data do not facilitate interpretation of the visual field.

**Colour or greyscale**

The colour scale aims to display sensitivity values in a map form in order that it can be more readily interpreted than numeric data (Figures 1 and 2). Ranges of sensitivity values are represented by different colours (dark...
colours indicating low sensitivity and light colours high sensitivity) or in shades of grey (black indicating low sensitivity and white high sensitivity). Sensitivity values are generally banded into 5dB groupings, with regions between the locations tested illustrated by interpolation. The disadvantage of colour scales is that a particular location in the visual field may have high sensitivity but may still be abnormal, or that a location may have depressed sensitivity relative to the surrounding locations which is suspicious, but all locations fall within a particular decibel grading colour and thus will not readily appear as a defect. A modification to the standard colour scale is used in the Field-View package, in which it is possible to view the colour scale as a fully rotational three-dimensional hill of vision in which colours indicate regions of sensitivity and the depth of scotomas is shown as changes in the relief of the hill of vision.

**Probability plots**

Probability plots are another form of graphical presentation of visual field data which are superior to examination of the numeric printout or colour-scale maps, because they make comparisons of measured sensitivity with age-matched normal sensitivity on a point-by-point basis yielding an outcome on the likelihood of a given location being normal or abnormal. In order to understand probability plots it is first necessary to understand the normal age-related decline in sensitivity of the visual field. The normal visual field reduces in height and becomes steeper as age advances. The normal decline in visual field sensitivity is on average approximately 0.7dB per decade and is thought to be due to a progressive age-related loss in photoreceptors and neural cells in addition to a general decrease in the clarity of the optical media reducing stimulus detection via light absorption and scatter. Figure 3 illustrates this decline in light sensitivity with age across the normal visual field at a central and a peripheral stimulus location.

There is a normal variation in light sensitivity for a given age with greater variation present in the peripheral than the central visual field. When presented with a range of normal values, it is possible to statistically define the arithmetic mean, but more importantly define confidence intervals for a normal population. The dotted lines in Figure 3 indicate the 95 per cent confidence interval. Within the boundaries of these confidence intervals, 95 per cent of all normal sensitivities are contained. If a sensitivity is measured in a patient and it falls outside this range, it will be assigned a P<5 per cent probability level, meaning that the measured sensitivity is normal in less than 5 per cent of the normal population (because the 95 per cent confidence limits contain 95 per cent of the normal value). Thus, probability plots graphically illustrate the level of statistical significance associated with a given visual field abnormality compared to the normal reference field. Visual field locations with statistically abnormal sensitivity do not necessarily mean that the measured sensitivity is abnormal, but there is a very high likelihood of it being so, particularly when probability symbols appear in clusters. The reasons for the abnormal sensitivity may be due to damage to the visual pathway but could also be due to factors such as inattention during the visual field examination, which is why the practitioner must consider this information in conjunction with other visual field analyses and clinical data when making a clinical interpretation.
In visual field analysis there are two types of probability plots, one sensitive to the detection of diffuse visual loss (the total deviation plot, Figure 4a) and the other sensitive to the detection of focal visual field loss (the pattern deviation plot, Figure 4b).

In the total deviation plot, the difference between the measured visual field sensitivity and the expected normal visual field sensitivity are plotted as a numeric map. A second plot illustrates those locations where the deviation is significantly different from the normal population, either at the $P < 0.5$ per cent, $P < 1$ per cent, $P < 2$ per cent or $P < 5$ per cent levels.

The pattern deviation probability map separates the general reduction in sensitivity which may arise through media opacities, optical defocus or pupillary miosis (total deviation) from the localised reduction in sensitivity. To calculate the pattern deviation probability map, locations within 24 degrees of fixation are ranked according to the deviation in sensitivity compared to the age-matched normal population. General sensitivity is calculated from the measured value of the seventh highest deviation (85th percentile) in sensitivity. The patient in Figure 2 clearly shows large areas of focal loss on the pattern deviation, consistent with a superior arcuate scotoma.

Over time these locations are likely to worsen with both the level of significance and the number of locations increasing. The probability map is therefore of use when monitoring a patient over time.

**Global visual field indices**

Graphical displays such as colour-scales suffer from a number of disadvantages, namely that they inadequately define diffuse visual field loss and changes between a series of visual fields. Statistical interpretation of perimetric data does not suffer from these disadvantages. Global visual field indices are a useful method of data reduction since they yield a single number which is an indication of the degree of diffuse or focal loss in the visual field. They are also of use when evaluating visual field change over time. A wide variety of visual field indices have been developed for the Octopus and Humphrey Field Analyser perimeters to summarise the data reduction at each stimulus location.

**Mean sensitivity**

Mean sensitivity (MS) simply represents the arithmetic mean of the measured sensitivity at all stimulus locations tested in the visual field. Since there is no reference to the patient’s age this index is of little use clinically.

**Mean defect and mean deviation**

The mean defect (MD) is the arithmetic mean of the difference between the measured values and the normal values at the different test locations. This statistic is employed in the Octopus and Henson perimeters. A positive MD represents a loss of sensitivity. The index is sensitive to diffuse visual field loss but is relatively unaffected by focal loss. Thus, in the presence of cataract, the MD will be increased.

The equivalent index used in the...
Humphrey Field Analyser is mean deviation, which is also abbreviated to MD. Mean deviation is a weighted average deviation from the normal reference visual field. A negative mean deviation represents a loss in sensitivity. It is important to check whether the MD index represents mean defect or mean deviation. In the presence of a large focal loss the MD will also be increased because a large number of locations will be depressed, which influences the mean sensitivity.

**Loss variance (standard deviation defect) and pattern standard deviation**

The loss variance (LV) statistic of the Octopus perimeter describes the non-uniformity in the height of the visual field. It is small if visual field damage is diffuse (eg in cataract) and is high in the presence of focal loss (eg in glaucoma or hemianopia). Variations in this index occur in other perimeters; in the Henson series it is called the standard deviation defect.

The pattern standard deviation (PSD) statistic of the Humphrey Field Analyser is a weighted standard deviation of the differences between the measured and normal reference visual field at each stimulus location.

It is analogous to loss variance and standard deviation defect. The patient in Figure 1 has a very small isolated area of focal loss and the PSD is unaffected. However, the patient in Figure 2 has a large area of focal loss reflected by the magnitude of the PSD.

**Short-term fluctuation**

The variability in the sensitivity which occurs when a threshold is estimated repeatedly during a single visual field examination is termed the short-term fluctuation (SF). In the Octopus perimeter, it is the average of the local scatter over the entire visual field, determined from the square root of the sum of the local standard deviations averaged over the visual field. Calculation of SF in this way assumes that the variance is constant at all locations in the visual field. However, the variance is known to increase with eccentricity. In the Humphrey Field Analyser, double determinations of threshold obtained at 10 locations in the visual field are used to calculate a weighted mean of the standard deviations (Figure 5).

The G1 program of the Octopus perimeter estimates the SF from double determinations of threshold at each location in the visual field, obtained over two phases. The 30-2 and 24-2 programs of the Humphrey Field Analyser estimate SF from double determinations of threshold obtained from 10 locations within 21 degrees of eccentricity. The SF is greater around the borders of a scotoma since small movements in fixation may result in the first and second threshold determination falling within and outside a scotoma respectively. Therefore, a high SF may be indicative of a pathological visual field.

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**MULTIPLE-CHOICE QUESTIONS** - take part at opticianonline.net

1. How are sensitivity values typically banded on a grey scale plot?
   - A 1dB groupings
   - B 5dB groupings
   - C 10dB groupings
   - D No grouping

2. For a patient with cataract but no isolated scotoma, which of the following will be true?
   - A They will show an overall reduction in the total deviation plot
   - B They will show an overall reduction in the pattern deviation plot
   - C They will show an overall reduction in the total and pattern deviation plot
   - D They will show an overall reduction in the total plot and a specific scotoma in the pattern deviation plot

3. For a patient with a cataract and an arcuate scotoma due to glaucoma, which of the following is true?
   - A They will show an overall reduction in the total deviation plot
   - B They will show an overall reduction in the pattern deviation plot
   - C They will show an overall reduction in the total and pattern deviation plot
   - D They will show an overall reduction in the total plot and a specific scotoma in the pattern deviation plot

4. For a patient with an arcuate scotoma but no media changes, which of the following is true?
   - A They will show an overall reduction in the total deviation plot
   - B They will show a specific reduction in the pattern deviation plot
   - C They will show an overall reduction in the total and pattern deviation plot
   - D They will show an overall reduction in the total plot and a specific scotoma in the pattern deviation plot

5. Within what extent of field is the pattern deviation probability map established?
   - A 5 degrees from fixation
   - B 12 degrees from fixation
   - C 24 degrees from fixation
   - D 48 degrees from fixation

6. For a patient with cataract, what will happen to the mean defect?
   - A It will be increased
   - B It will be decreased
   - C It will remain constant
   - D It is of no interest as it bears no relevance to the patient’s age

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SUCCESSFUL PARTICIPATION IN THIS MODULE COUNTS AS ONE CREDIT TOWARDS THE GOC CET SCHEME ADMINISTERED BY VANTAGE AND ONE TOWARDS THE ASSOCIATION OF OPTOMETRISTS IRELAND’S SCHEME.

The deadline for responses is July 12 2012

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