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# Evaluation of the Friedmann Visual Field Analyser Mark II. Part 1. Results from a normal population

DAVID B. HENSON,[1] SANDRA M. DIX,[1] AND ALAN C. OBORNE[2]

*From the Departments of [1]Optometry and [2]Computing at the University of Wales Institute of Science and Technology*

SUMMARY Normal subjects when examined with the Friedmann Mark II Analyser often miss stimuli in the extreme (greater than 20°) superior field and in the arcuate regions. The majority of misses in the superior field are believed to result from the subjects' eyelashes acting as partial occluders. The misses in the arcuate region are believed to be the result of the retinal blood vessels. Isolated missed points at 0·8 or more log unit above threshold were found in 9% of the subjects, which means that it is 13 times more likely that an isolated missed point comes from a normal subject than a glaucomatous one (the incidence of glaucoma is taken as 0·7% of the total population). Clusters of two missed stimuli in the arcuate region at 0·4 and 0·6 log unit above threshold were found in 8% and 0% of the population. Clusters of three missed stimuli in the arcuate region were found in 0·7% of the population. It is suggested that isolated missed stimuli should be retested with the eccentric fixation point.

The Friedmann Visual Field Analyser Mark II was introduced by Friedmann in 1979.[1] It is a multiple stimulus screener which presents a series of patterns composed of either two, three, or four stimuli. Each stimulus pattern is selected by the rotation of a fenestrated plate behind a second stationary fenestrated plate. Light will pass through these plates only when the fenestrations coincide. A single xenon discharge tube placed within an integrating bowl, the front of which is occluded by the two plates, is the light source for all the stimuli. This light source presents a flash of light the approximate duration of which is 0·25 ms. The fenestrations in the front plate increase in size towards the periphery of the field to account for the normal gradient of sensitivity across the retina. The intensity of all the stimuli can be altered by placing neutral density filters in front of the xenon bulb. This enables a defect to be quantitatively measured and also allows the perimetrist to adjust the stimulus intensity to account for individual variations in sensitivity. The main differences between the Mark II analyser and the earlier Friedmann Visual Field Analyser (now designated the Mark I) are that there are over twice as many stimuli in the Mark II (98 versus 46), and that a chart holder has been attached to the side of the instrument. Within the chart holder there is a series of light sources that indicate to the perimetrist the position of the aligned fenestrations.

A technical and clinical evaluation of the VFA Mark II was conducted by De Boer *et al.*[2] These researchers examined 106 eyes, 13 of which were from normal subjects. Of the remaining 93 eyes 31 were glaucomatous, 34 had maculopathies, and 26 had other miscellaneous field defects. De Boer *et al.* reported that the instrument was both sensitive and selective to early visual field defects and that the examination time was short provided the eye was either normal or had a mild defect. When the visual defect was large, the duration of the examination was long reaching up to 20 min/eye. They also reported that the examination chart was overcrowded and difficult to interpret. Batko *et al.*[3] have also conducted a clinical trial with the VFA Mark II. They again found that the instrument was both sensitive and selective to glaucomatous defects (infact they found it to be slightly more sensitive than the Goldmann perimeter). Their subjects were divided into three groups—normal controls, glaucomatous, and unknowns. The normal control group was used to

Correspondence to D. B. Henson PhD, Department of Optometry, UWIST, Colum Drive, Cardiff CF1 3EU.

establish criteria that would result in very few normal people failing the test. Their criteria were (1) to fail anybody who missed one or more stimuli at 0·8 log unit above a patient's working threshold, other than those that fall in the blind spot region; (2) to fail anybody who missed a group of points at 0·4 or more log unit above the working threshold; and (3) to treat with suspicion anybody who missed one or more points at 0·6 log unit above the working threshold within the central 12·5° of the field. Batko *et al.* reported that in the peripheral field a high proportion of normal subjects missed stimuli at 0·6 log unit above the working threshold, and it is for this reason that they adopted criterion 3 rather than one which treated all points missed at this value as equivocal. The clinical trial of Batko *et al.* was primarily directed at establishing how sensitive and selective the Mark II analyser is at detecting early glaucomatous damage, and it is possibly for this reason that they chose not to describe in detail the results of their normal subjects. It is the purpose of this paper to present the results from a group of normal subjects examined with the Friedmann Mark II analyser. The results are valuable to both the ophthalmologist and the optometrist in that they indicate what the normal variability in response is and also the frequency with which each stimulus is missed. These data are utilised in the second paper[4] to establish a set of criteria that can be applied to any subsequent set of field data that will indicate the probability that it comes from a normal individual.

## Material and methods

The threshold of each subject was established by repeatedly presenting approximately 30 stimuli at different intensities (0·2 log unit steps). These stimuli covered the whole 25° of the visual field. The threshold was taken as the intensity at which 20-30% of the stimuli were missed. All the stimuli were then presented at the threshold. Any missed points were retested at this setting. Each missed stimulus was then repeatedly tested at intensities which increased in 0·2 log unit steps until either it was seen or the limit of the instrument was reached. One hundred and fortysix eyes were examined in this way from a group of subjects, the majority of whom were university students.

The results of each examination were entered into a computer for analysis on completion of the trial. The computer kept a record for every subject of the stimuli missed at threshold and, if seen at higher intensities, the intensity at which they were seen. These data were used to calculate the relative density of misses for each stimulus. This involves calculating how many subjects miss each stimulus at 0·2, 0·4, 0·6, and 0·8 log unit above threshold. These values are then summed, for each stimulus, and then divided by the maximum sum (obtained from one of the blind spot points) in order to give a value of between 0 and 1.

The results from left eyes were reversed so that they could be pooled with those from the right eyes.

## Results

The relative density of misses for all the stimuli (with the exception of one stimulus which will be discussed later on in this section) have been combined into the single three-dimensional surface fitting plot of Fig. 1. The large peak in this figure corresponds to the blind spot. Individual variations in the positioning of the blind spot mean that this region of the field is not a flat topped ellipse but peaks at one stimulus location (13·8° to the right and 1·2° below the fovea). This stimulus was missed by 70% of normal subjects at 1·8 log units above their thresholds. If the points that fall within the blind spot marked on the VFA Mark II charts are removed from the analysis, the surface fitting plot is altered to that shown in Fig. 2. Here an ellipse representing the whole of the blind spot marked on the VFA chart has been set at zero. The residual peaks above and below this ellipse demonstrate that a large proportion of normal subjects miss points that fall beyond the marked blind spot region of the chart. If the points directly above and below those falling within the marked blind spot ellipse for the right eye and those directly above and just to the

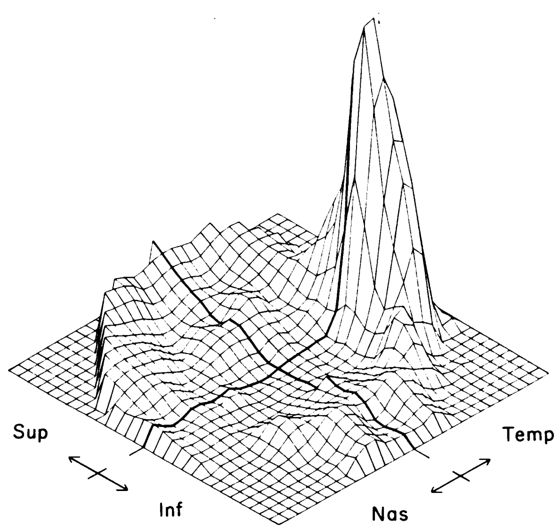


Fig. 1 *The relative density of misses calculated from 146 normal eyes. All stimuli are included with the exception of the one positioned 23° to the left and 9·5° above the fixation point.*

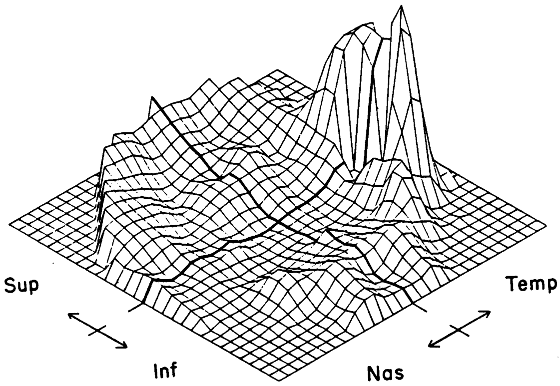


Fig. 2 *As for Fig. 1 with the exception that stimuli falling within the marked blind spot region of the Friedmann chart have been excluded.*

left of the blind spot of the left eye are also removed from the analysis, the surface fitting plot is altered to that shown in Fig. 3. In this figure there is no obvious residual peak around the blind spot region, and it can be assumed that for the vast majority of normal subjects the blind spot does not extend beyond the region of the field represented by the 4 stimuli removed from the analysis.

Figs. 1, 2, and 3 all show that the relative density of misses is greater in the superior field than it is in the inferior field. Fig. 4, which is a plot of the same data as those given in Fig. 3 but viewed from a different direction, emphasises this point. If shallow defects, those less than 0·6 log unit above the working threshold, are removed from the analysis, there remains only a slight increase in the frequency of misses in the superior field. This residual increase is believed to be due to either the eye lid or brow occluding these stimuli in a small percentage of subjects. The high frequency of misses at 0·2 and 0·4 log unit above the working threshold is believed to be due to the eyelashes partially occluding and thereby attenuating these stimuli.

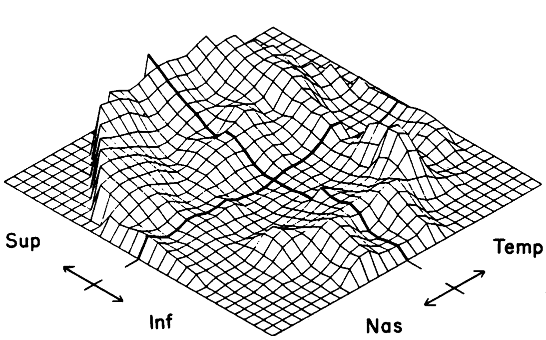


Fig. 3 *As for Fig. 2 with the exception that the stimuli falling directly above and below the marked blind spot region for the right eye and those directly above and just to the left of the blind spot region for the left eye have also been excluded.*

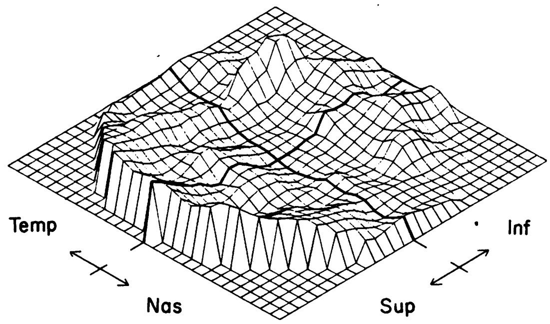


Fig. 4 *As for Fig. 3 only viewed from a different direction.*

In addition to the higher relative density of misses in the superior field all figures show an area of increased misses that spreads from the blind spot and encircles the fovea. The annular course of this area follows that of the superior and inferior temporal retinal vessels, indicating that it is most likely the result of angioscotoma.

The stimulus 23° to the left and 9·5° above the fixation point was missed by a large percentage of normal subjects at intensities 0·4 and 0·6 log unit above the working threshold. This finding was interpreted as the result of an instrument malfunction, as it was independent of the eye examined and much higher than the number of misses recorded for stimuli at equivalent distances from the fovea. Examination of the instruments front plates did not reveal anything occluding the fenestrations that are responsible for this stimulus, and hence the high frequency of misses was interpreted as the result of incorrectly sized fenestrations.

## Discussion

One of the criteria set by Batko *et al.*[3] was to fail any subject who missed one or more stimuli, other than those that fall within the blind spot region, at 0·8 or more log unit above threshold. Our results indicate that, even after disregarding the 4 blind spot stimuli and the one peripheral stimulus that had an incorrectly sized aperture, 9% of normal subjects miss one or more stimuli at this setting. The most frequent location of these points were in the superior visual field, beyond 20° from the fixation point, and in the arcuate regions above and below the blind spot. The majority of the misses in the superior visual field are believed to be the result of the subjects' eyelashes acting as partial occluders to these stimuli. The misses in the arcuate regions are believed to be the result of the blood vessels occluding the visual cells.

These angioscotomas are particularly worrying to the perimetrist, as they fall within that region of the visual field where glaucomatous defects often occur.[5-7] Fortunately angioscotomas usually produce missed stimuli that are isolated from each other. In none of the 146 eyes tested within this survey were two adjacent points missed in this region of the visual field at 0·6 or more log unit above threshold. If the ophthalmologist ignores isolated missed stimuli in these regions of the visual field, it is highly unlikely that he will falsely diagnose a defect in a normal subject. Ignoring isolated missed stimuli is, however, worrying when consideration is taken of how large a scotoma has to be for it to cover more than one stimulus. A simple computer evaluation of the stimulus locations of the Friedmann Mark II Analyser reveals that a scotoma has to have a diameter in excess of 5° in order to get a 50% chance of it covering 2 or more stimuli. The results of the computer analysis are given in more detail in Fig. 5.

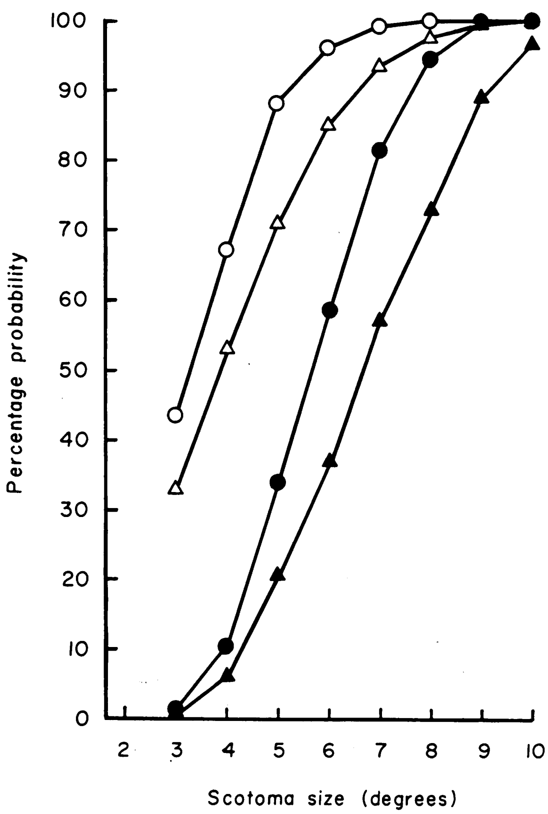


Fig. 5 *The probability of one (○ △) or two (● ▲) Friedmann Mark II stimuli falling within a given sized circular scotoma. The triangular symbols (△ ▲) are for the whole 25° tested by the VFA while the circular symbols (○ ●) are for the central 20° of the field.*

The ordinate represents the probability of either one or two stimuli falling within the area of a circular defect, while the abscissa represents the diameter of the defect. Two sets of data are given, one for the whole of the 25° area tested by the Friedmann Analyser and one for the central 20° of the field. This evaluation predicts, for a scotoma the size of the blind spot (5° by 3°) that approximately 45% of normal subjects would miss one or fewer stimuli. Analysis of the results from this survey show that 52% of the subjects missed one or fewer stimuli in the blind spot region.

Similar types of analysis have been conducted on other pieces of visual field equipment, and, as would be expected, the probability of detection increases with the number of stimuli. There is, however, a practical limit to the number of stimuli that can be tested within a visual field examination. If too many stimuli are used, the patient becomes bored and unreliable. Added to this there is the problem that, given finite resources for visual field examination, the longer an examination takes the fewer can be conducted. The number of stimuli used in the Friedmann Mark II Analyser may therefore be close to the optimum number when the dual considerations of speed and sensitivity are considered.

The results of the computer analysis emphasise to the clinician that by ignoring a single missed point the test becomes insensitive to early defects. On the other hand the results also indicate that a significant percentage of normal subjects miss a single stimulus. One solution to this problem is to use the eccentric fixation device provided with the instrument. This device moves the fixation point 2° in any chosen direction and thereby alters the retinal position of all the stimuli by 2°. Retesting with this device allows the perimetrist to differentiate between scotomas that are greater than 2° and those smaller than 2°, such as angioscotoma.

The second criterion used by Batko *et al.*[3] to differentiate between 'normals' and 'defectives' was to fail anybody who missed a group of stimuli at 0·4 or more log unit above the patients threshold. The results from this survey indicate that 13% of normal subjects miss two or more adjacent stimuli at this intensity setting. For the purposes of this evaluation stimuli were considered adjacent if they fell within 7·5° of each other. Several of the clusters were due to the eyebrow or eyelid occluding stimuli as they were more than 20° from the fovea and in the superior field. If these clusters are removed from the analysis, the residual number of subjects with clusters reduces to 8%. All of these clusters fell within the arcuate region of the visual field and are typical of the type of field loss seen in early glaucoma. Batko *et al.*[3] do not mention whether the missing of two adjacent stimuli was sufficient to warrant a positive response. They merely stated that there should be 'several adjacent shallow misses. . . .' If this is interpreted as meaning three or more stimuli, the results from our study indicate that only 0·7% of normal subjects would meet this criterion.

The size of the stimuli used in the VFA increases towards the periphery of the visual field in order to account for the gradual loss in sensitivity that occurs towards the periphery of the retina. This facility increases both the sensitivity and the specificity of the instrument by making it possible to set all stimuli at a given suprathreshold value irrespective of their location within the visual field. Greve[8] reported that the stimulus sizes in the Mark I VFA were incorrect to compensate for the normal gradient. He stated that the central stimuli were too large and those at 15° from the fixation point too small. Reducing the data from this evaluation to a single two-dimensional plot where the ordinate represents the average number of times stimuli were missed at 0·2 log unit above the threshold, and the abscissa represents the distance from the fixation point, demonstrates that the central stimuli are less frequently missed than those either in the mid or far periphery of the visual field (Fig. 6(a)). Stimuli falling within the blind spot region and the one faulty stimulus already mentioned were not included in this analysis. The results for the stimuli beyond 20° are heavily biased by those in the superior field which were frequently missed as a result of the eyelashes. If these are removed from the analysis, the results appear as in Fig. 6(b). This figure demonstrates that the stimuli between 15° and 20° from the fixation point are much more frequently missed than those both closer to the fixation point and further away from it. This high frequency is not solely the result of incorrectly sized fenestrations. As mentioned previously the large number of retinal blood vessels in this region of the retina increases the probability of an angioscotoma.

The majority of the subject's blind spots fell within the region of the field covered by the four points removed from the analysis for Fig. 3. One subject missed two stimuli that fell to the foveal side of these four points. This subject had a high spectacle corrected refractive error which resulted in an optically displaced blind spot.

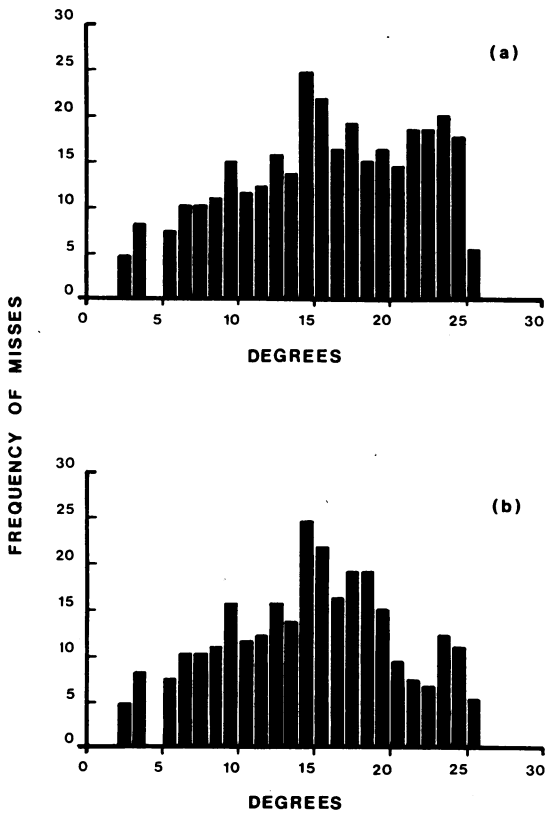


Fig. 6(a) *The frequency with which stimuli at different distances from the fixation point are missed at 0·2 log unit above threshold. Stimuli falling within the blind spot region and the stimulus 23° to the left and 9·5° above the fixation point have been excluded.* (b) *As for Fig. 6(a) with the exception that stimuli in the superior field 20-25° from the fovea have also been excluded.*

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