ASSESSMENT OF VISUAL FIELD ANOMALIES USING THE VISUALLY EVOKED RESPONSE

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Abstract

A study was performed to assess visual fields using the Visually Evoked Response (VER), by both check and flash methods.

Ten normal subjects were tested using simulated defects, and subsequently patients with various field defects were assessed. Characteristically abnormal VER responses were found for several gross field defects, especially hemianopias, central scotomas and tunnel vision. Smaller defects such as quadrantinopias were assessable by the check VER only but they require more careful interpretation of the results.

The value of using the VER as an alternative method of visual field assessment, with the mentally retarded, geriatric and uncooperative patient is demonstrated.

Key words: *Visually Evoked Potential (VEP), handicapped patient, simulated defects, hemianopia, quadrantinopia, central scotoma, tunnel vision.*

INTRODUCTION

The Visually Evoked Response (VER) or Visually Evoked Potential (VEP), is primarily used in the diagnosis of conditions affecting the optic nerve and the visual cortex. It shows whether or not stimuli seen by the eye reach the cortex without delay and with correct magnitude (i.e. no reduction in strength).

There are many patients whose visual fields cannot be assessed by the conventional field testing methods. They include mentally retarded or emotionally disturbed patients, patients with communication problems, malingerers, some geriatric patients, babies and the very young. If the patient is cooperative enough to have a VER test performed, any gross visual field defect should be detected.

For a check VER to be performed a certain amount of cooperation is required as the patient is required to fix on a central spot. However, no other responses are required from the patient. With the flash VER there is no patient age limit as babies may be sedated while the test is performed. The patient is only required to sit at a Ganzfield sphere and keep his eyes open or have the lids held up if sedated.

Generally the VER is advantageous with some difficult patients as there are very few instructions necessary for the patient. The test is performed more quickly on average than conventional methods of perimetry and it is much easier for both patient and examiner.

The aim of this paper is to make orthoptists aware that the VER may be used as a gross visual field assessment method for patients when conventional methods are unsuccessful.

Before continuing, the normal VER testing procedure will be outlined.

In the normal individual any visual stimulus causes an electrical signal in the brain. The VER is the recording of this signal. The recording basically originates from the nerve fibre layer in the retina and is recorded from the visual cortex. The VER is recorded monocularly.

There are two types of VER's

(1) Check VER

(2) Flash VER.

With the check VER the patient is required to fix on a central spot on the checkerboard while the check pattern alternates (see Fig. 1). Vision

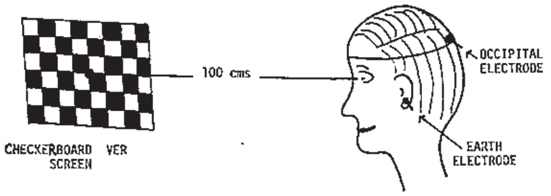

Figure 1: Checkerboard V.E.R.

of 6/36 is normally required for the patient to see the spot on the checkerboard. A 32° or 16° area of the visual field is stimulated with one of two different check sizes. An average of 64 check reversals was recorded in each case.

To perform the flash VER the patient is seated looking into a Ganzfield sphere (see

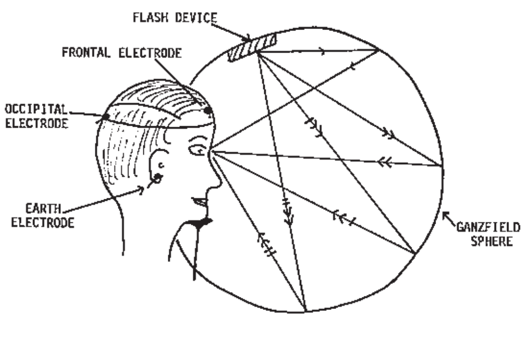

Figure 2: The flash V.E.R.

Fig. 2). Bright flashes of light occur approximately every two seconds. In this test the whole field is stimulated and, since the Ganzfield sphere is manoeuvrable, unconscious patients and babies may be assessed. (An average of 64 flashes were recorded in each case.)

When considering the VER results, the latency and amplitude of the curve are taken into account as well as the overall shape of the curve (see Fig. 3).

Latency, or the time taken for the stimuli to travel along the optic nerve to reach the occipital cortex is measured in milliseconds (ms) or 1/1000 second. With the normal subject (in the author's lab) it takes approximately 95 ms for the check response to reach the visual cortex and it takes approximately 77.0 ms for the flash response. This is reflected in the curve as the first major positive peak and is marked as point "1" and is commonly known as $\overline{P100}$ (P=Positive).

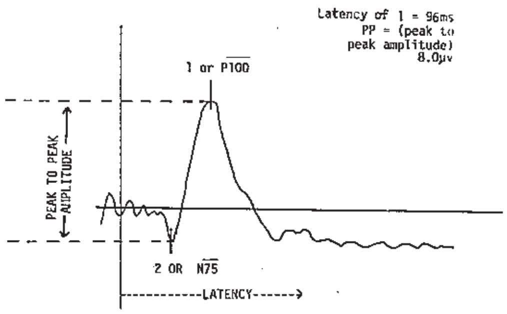

Figure 3: The normal V.E.R.

The amplitude or intensity of the stimulus reaching the visual cortex is measured in microvolts (μv) or 1/100000 volts. In the normal subject the amplitude of $\overline{P100}$ is 8.0 μv for the check VER (see Fig. 3) and 4.8 μv for the flash VER.

Point "2" or $\overline{N75}$ is also generally marked. It is the major negative point which occurs prior to point "1" (see Fig. 3).

METHOD

Two groups of patients were examined.

Group 1: Consisted of 10 normal subjects. Each of the patients were ophthalmologically normal with full visual fields and corrected VA of 6/6 or better. Only the right eye was tested.

Group 2: Consisted of 11 patients with field defects detected on the Goldmann perimeter or Bjerrum screen.

This group included:

3 hemianopic patients
7 patients with tunnel vision
1 arcuate scotoma.

For the purpose of detecting field defects an occipital electrode is placed on the occipital lobe 5 cms above the inion (over the calcarine sulcus). This electrode mainly detects the maximal response of each occipital lobe with the largest contribution coming from the macular fibres (see Fig. 4).

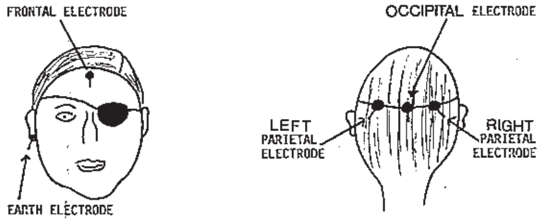

Figure 4: Electrode placement used.

Two parietal electrodes were also used; each placed 5 cms horizontally on either side of the occipital electrode. Recordings from the temporal and nasal halves of the retina were taken individually from these two electrodes thus detecting responses from both nasal and temporal half fields.

The reference electrode was placed on the forehead 6 cm above the nasion and an earth electrode was placed on one ear (see Fig. 4). Once in place these electrodes were not moved throughout the course of testing.

The same arrangement was used for both the normal group and the group with field defects. All patients had both check and flash VER's performed.

For the patients in group 1 field defects were simulated by blocking the appropriate areas of the screen (see Fig. 5) for the check VER. The subjects were instructed to look straight ahead all the time so that they did not overcome their simulated defect.

Simulation of field defects for the flash VER was attempted by blocking out the appropriate area on a lens placed in front of the eye to be tested. This proved unsuccessful as the lens distance (1 cm) from the cornea allowed light to reach all parts of the retina. Thus the only effect was to decrease the intensity of stimulation from one part of the field. Accordingly no VER flash results from normal patients with simulated field defects are recorded.

RESULTS

The results are divided into groups according to the field defect. Each group is further subdivided into normals and patients with actual field defects.

Because of patient to patient variation in VER recordings, an average of responses for normal subjects is taken and referred to in the following figures.

The amplitude in the figures is a peak to peak amplitude, (P to P), i.e. the difference in the height of the tracing between points "1" and "2" (see Figure 6).

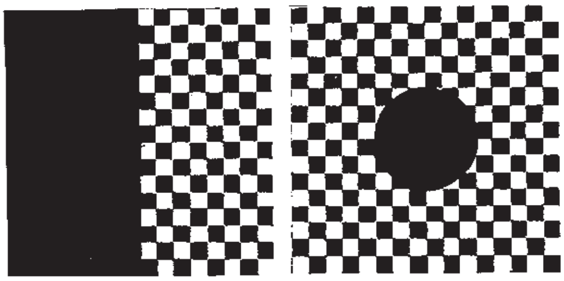

Figure 5: (a) Simulated hemianopia; (b) Simulated central scotoma.

All the results were compared to the average whole field stimulation of normal individuals. (The averaged curves for normal subjects were smoother due to filtering and averaging.)

Check VER-Whole Field Stimulation: The averaged whole field stimulation of normal subjects showed the latency of point "1" to be 94.0 ms for the occipital electrode and 96.0 ms for the parietal electrodes (see Figure 6). The amplitude recorded from the occipital electrode was 8.0 μv, while 3.2 μv was recorded from the parietal electrodes.

Flash VER-Whole Field Stimulation: The average latency recorded from the flash VER was 77.0 ms from the occipital electrode, 76.0 ms from the right and 78.0 ms from the left parietal electrode. (See Figure 7). The amplitude recorded from the occipital electrode was 5.2 µv and 4.6 µv recorded from the parietal electrodes.

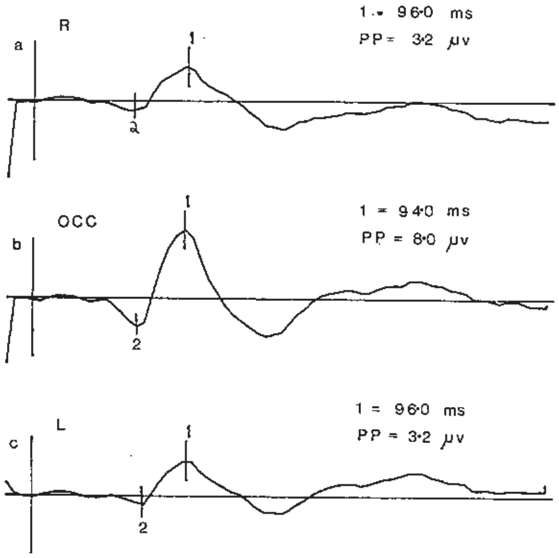

Figure 6: Tracing of check whole field stimulation. (Normal subject: Right eye). Symbols 1 = . . ms, in this and subsequent tracings represent latency of first positive peak.

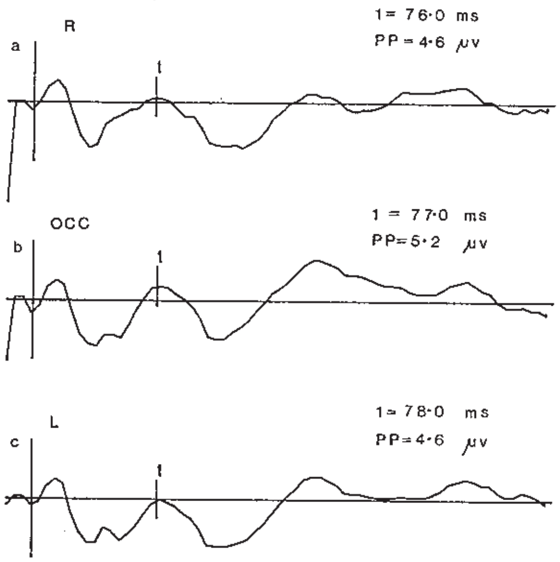

Figure 7: Tracing of flash whole field stimulation. (Normal subject: Right eye.)

Hemianopia

(1) Normal Subjects — The greatest difference between the averaged whole field tracing and the averaged hemianopia was seen in the electrode ipsilateral to the side of the field defect where there was an increase in latency to 110.0 ms and a decrease in amplitude to 0.6 µv (see Figure 8). There was a decrease in amplitude to 4.8 µv recorded from the occipital electrode while the latency remained unchanged (Figure 8b). The tracing from the electrode contralateral to the side of the defect remained within normal limits (Figure 8c).

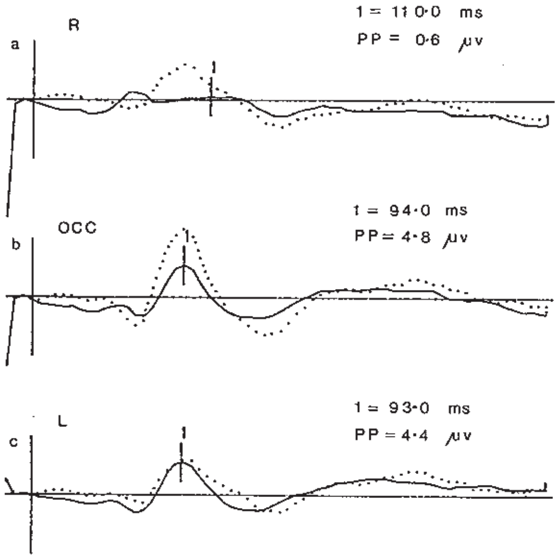

Figure 8: Check VER tracing of simulated right hemianopia. Right eye.

The fact that the greatest change occurred in the tracing recorded from the electrode ipsilateral to the side of the field defect is to be discussed.

The averaged responses for both the simulated right and left hemianopias on the check and flash VER demonstrate the above.

Simulated hemianopias with 5° macular sparing produced tracings with characteristics similar to the above, however, the changes were not as marked.

(2) Hemianopic Patients — When tested with the check and flash VER's they also demonstrated results similar to the above (Figure 9). As with the normal subjects there has been an increase in latency and decrease in amplitude recorded from the electrode ipsilateral to the side of the field defect (Figure 9a).

The amplitude is decreased in the recording from the occipital electrode (see Figure 9b) and the recording from the electrode contralateral to the side of the field defect is essentially unchanged.

These changes were not nearly as consistent with the flash VER as with the check VER.

(NB. — All tracings have the averaged whole field for the normal subjects superimposed in a dotted line.)

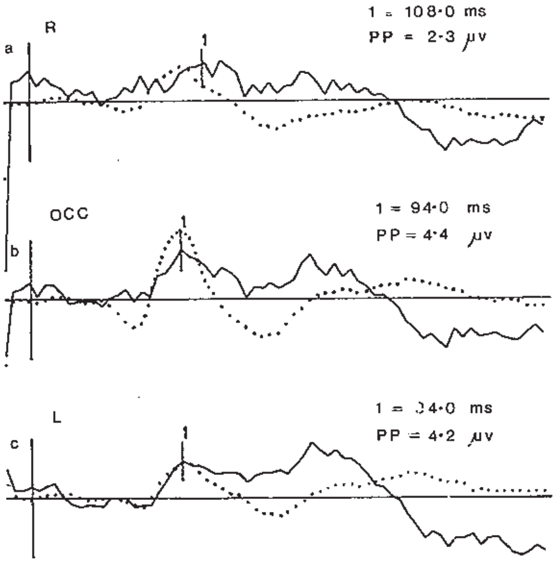

Figure 9: Check VER tracing of actual right hemianopia: Right eye.

Quadrantinopia

(1) Normal subjects — The average of the results recorded from the simulated quadrantinopic field defects tested with the check VER demonstrated the following changes. Firstly, in the tracing from the electrode ipsilateral to the side of the field defect there is a slight decrease in amplitude (1.3 μv) and an overall flattening of the curve. Also, there is a reversal in polarity of point "2" or $\overline{N75}$ i.e., it became a positive peak rather than a negative peak (Figure 10c — left quadrantinopia). The recording from the occipital electrode shows a loss of point "2" (Figure 10b). The recording from the electrode contralateral to the side of the field defect is within normal limits (Figure 10a).

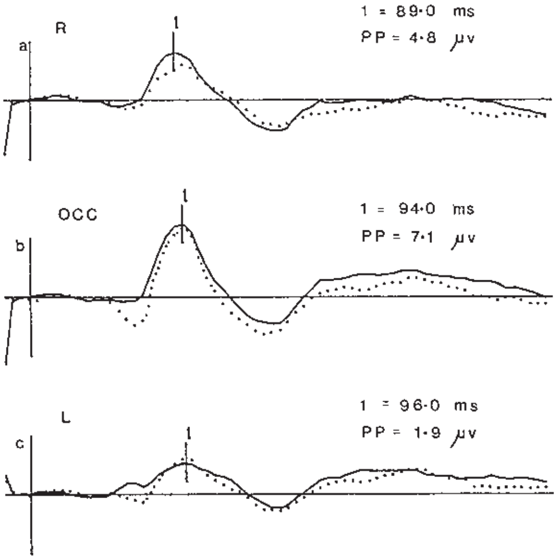

Figure 10: Check VER of simulated left superior quadrantinopia. Normal subject: Right eye.

Results obtained from simulated quadrantinopias with 5° macular sparing were similar to the whole field tracings.

(2) No quadrantinopic patients were tested.

Central Scotoma

(1) Normal subjects — The simulated 5° and 10° central scotomas tested with the check VER demonstrated latencies equal to the whole field latencies recorded from all channels (Figure 11). There was also a significant reduction in amplitude recorded from all electrodes with the most significant reduction of 5.1 μv being recorded from the occipital electrode (Figure 11b).

This reduction in amplitude was greater from all electrodes in the averaged 10° scotoma than the averaged 5° scotoma, i.e. the larger the scotoma, the more obvious the change.

(2) No patients with actual central field defects were available for testing.

Tunnel Vision

(1) Normal subjects — All cases of simulated tunnel vision showed an increase in latency of point "1" and a decrease in amplitude from all electrodes (Figure 12).

The amplitude decrease was again more marked in the gross field defect, i.e., the smaller tunnel of vision caused more obvious changes in the tracing.

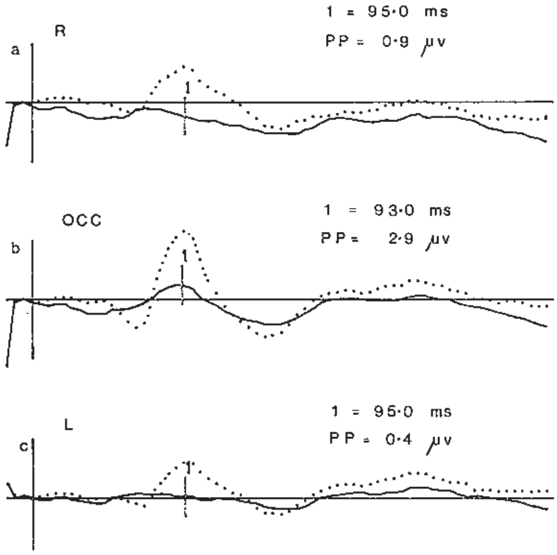

Figure 11: Check VER tracing of simulated 10° central scotoma: Right eye.

(2) Patients with tunnel vision — Seven patients with tunnel vision were tested. Three of the patients had 20° tunnel vision. For these three patients the results of the check and flash VER results are almost the same as the whole field tracings.

The other patients all had more marked tunnel vision (up to 5° tunnel in three cases). They all showed an increase in latency and a decrease in amplitude in a manner similar to the above (Figure 13).

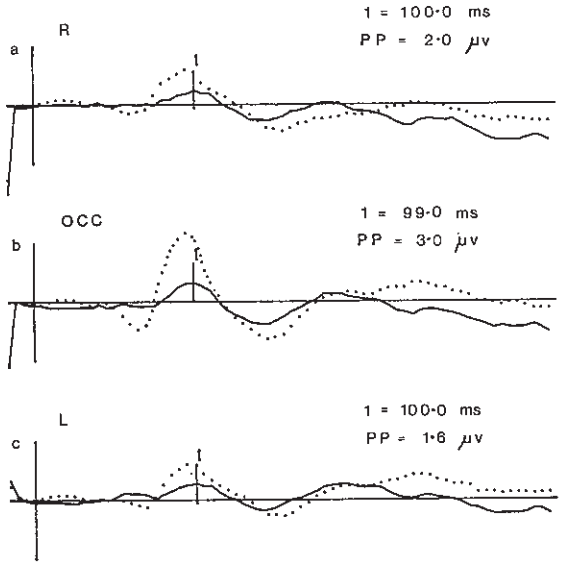

Figure 12: Check VER of simulated 5° tunnel vision: Right eye.

Arcuate Scotomas

In both normals and the patient tested with an arcuate scotoma, there was no detectable difference between the tracings obtained and the whole field tracings for both check and flash VER's.

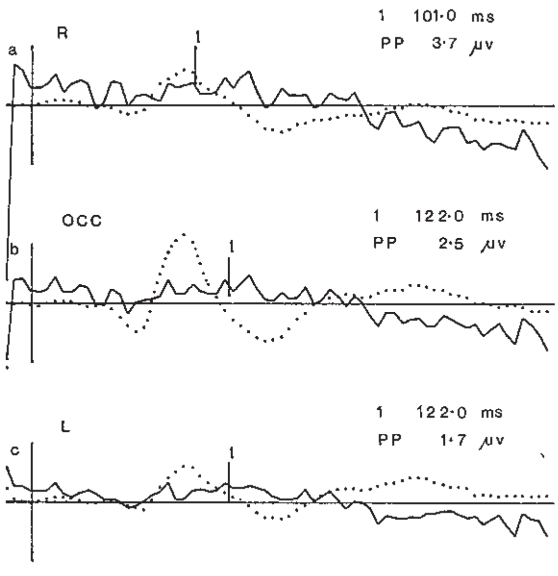

Figure 13: Check VER tracing — patient with 5° tunnel vision. Right eye.

In all cases in this study the defects recorded from the checkerboard covering 32° of the visual field showed more marked trends than those recorded from the 16° checkerboard.

DISCUSSION

Studies by Blumhardt *et al.*[1] who investigated half field stimulation with the check VER demonstrated that point "1" or $\overline{P100}$ in the VER tracing "actually arises in the hemisphere contralateral to the stimulated half field but are recognised from the ipsilateral scalp due to the orientation of generator neurones on the posterior-medial aspect of the visual cortex".

Records obtained in this study are similarly paradoxical. For instance, in the case of a right hemianopic defect (figure 9) the recording from the ipsilateral (right) parietal electrode shows a marked decrease in amplitude. However, the left visual cortex would in fact be receiving the decreased input and is showing a normal tracing. Thus the recording from the electrode ipsilateral to the side of the field defect shows the marked changes.

In this and other studies hemianopic defects were most easily detected and, the author has found that the VER can successfully be used in the diagnosis of such defects. This is so because no response is generated in the occipital lobe ipsilateral to the field defect except duplicated macular representation.

Quadrantinopias require extremely careful analysis of results to be detected, however the reversal in polarity of point "2" or $\overline{N75}$ coupled with the flattening of the ipsilateral parietal tracings are characteristic.

Macular sparing was almost impossible to detect as there was very little appreciable difference between the tracing with macular sparing and the whole field tracings. However, it may well be the case that subtle changes in $\overline{N75}$ may illustrate macular sparing.

In this study central scotomas were easily detectable on the check VER. It was shown that the larger the scotoma, the greater the decrease in amplitude of $\overline{P100}$, especially from the occipital electrode. (This is due to the larger representation of central fibres at the occipital pole.)

At this stage only gross tunnel vision can be detected (less than 15° tunnel) on either check or flash VER. Check results are again more consistent than flash results.

Arcuate scotomas were undetectable in this study.

CONCLUSION

This study has shown that field defects can be demonstrated using the VER, but in order to do this the limits of the normal range of latency and amplitude must be known (through testing a large population of normals).

Careful analysis of the results in cases of small field loss is necessary. Gross defects on the other hand require little effort in interpretation.

So far the check VER has proven more valuable than the flash VER in the detection of field defects. With further careful analysis of the flash VER recordings and many more recordings from patients with field defects, defect trends may become more apparent with the flash VER.

For any particular patient, if a response can be gained by conventional methods of perimetry, such a patient should not be considered for field assessment with the VER as conventional methods give an accurate assessment of the size of the defect. However, the VER definitely has a place in field assessment for those patients unable to have conventional perimetry.

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