THE VISUAL EVOKED RESPONSE AND STEREOPSIS

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Abstract

Although the visual evoked response (VER) has been used as a tool in research and clinical practice for many years, it has only recently become possible to use the VER to achieve an objective measure of stereopsis. This method of evaluation has great potential, particularly for use with patients who have limited ability to communicate visual impressions to the examiner. The authors are using dynamic random dot stereotests in association with VER recording and analysis to evaluate stereopsis comprehensively. Methods and results are considered.

The visual evoked response (VER) has been used as an aid in the diagnosis of such conditions as optic neuritis,[1] retrobulbar neuritis,[2] multiple sclerosis,[3] progressive spastic paraplegia,[4] compression of the anterior visual pathways[5] and colour blindness.[6] The aim of this paper is to introduce another area of application of the VER which should be of particular interest to the orthoptist: the objective evaluation of stereopsis.

Methods of evaluation which use the VER have several advantages over more subjective techniques. The method gives an objective measure of patient response as it is not necessary to rely on verbal report to determine the result of a trial. It is also possible to use one channel of the electrophysiological recording equipment to check for eye movements. This allows eye fixation to be monitored, a necessary precaution if stimulation is occurring in peripheral visual fields. It is very instructive to record VERs to stereoscopic stimuli presented at the visual periphery, as it is sometimes found that a patient with normal response to a central stimulus will fail to respond to a stimulus which lies in, for example, the right visual field.[7]

Dynamic random dot stereograms have been used as a stimulus for visual evoked responses since 1978[8] and several studies have presented results since that time (e.g.,[9-13]). Each of these studies used computer generated dynamic random-dot stereopatterns in conjunction with display systems which had relatively limited ability to cope with patients who had significant ocular deviations. The authors of the present study have developed a display system which is intended to be used with orthoptic patients as well as normals. The system is built around a Clement Clarke Synoptophore and has been described in some detail elsewhere.[7]

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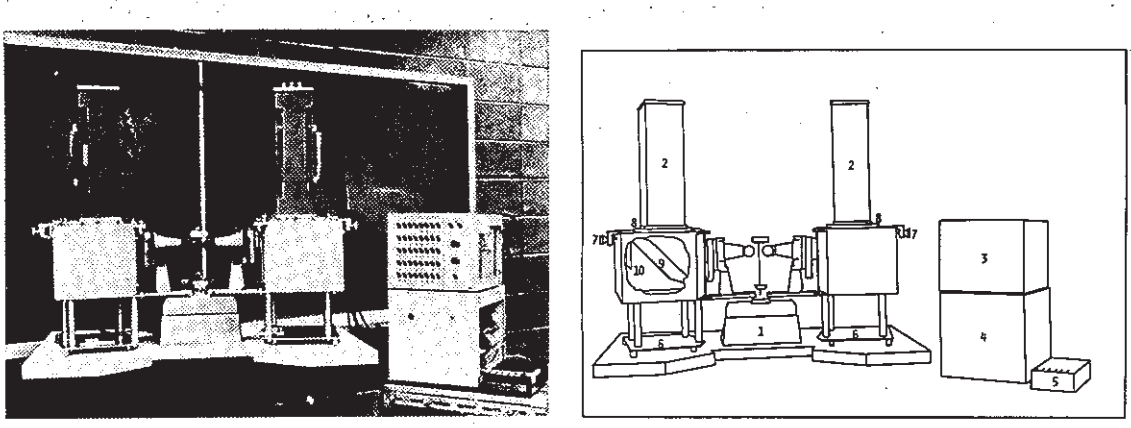

Figure 1: Photograph (a) and Schematic (b) of test instrumentation. Components are as follows: (1) Clement Clarke Synoptophore; (2) Display units; (3) Hardwired display generator; (4) Microcomputer; (5) Cassette unit for storage and retrieval of programs; (6) Support trolleys; (7) Height adjustment; (8) Torsion adjustment; (9) Half-silvered mirror; (10) Fixation matrix.

The unit is illustrated in Figure 1. It has adjustments for interpupillary separation (45-75 mm), vergence angle ($\pm 25°$ each side), torsion ($\pm 25°$ each side) and vertical vergence (± 1 prism dioptre each side). The range of adjustments is suitable for the majority of patients with the addition of accessory vertical prisms. The viewing distance is 400 mm and accommodation is relaxed to approximate infinity with eyepiece lenses (+2.25 dioptre). The images of the display units are reflected from half silvered mirrors. Red fixation lights lie behind the mirrors and are thus superimposed on the images of the display units. The vertical height adjustment acts on the fixation lights and the display units so that both remain aligned at all times. The fixation markers can occupy any one of eight positions. By changing the eyepiece lenses, the synoptophore can be used in standard form.

The random-dot displays normally subtend an angle of just over 10° (150×256 sec. of arc), but by inserting a lens combination into the slide holders and filter slot, the subtense can be altered to just over 2° (30×256 sec of arc). The instrument can therefore be used to test responses to either a foveal stimulus or a more peripheral stimulus.

As has been discussed elsewhere,[14] the authors' system does not use a computer to generate the displays as such, but rather uses a microcomputer controlled, hardwired display generator. This gives the system a far greater dot generation rate (up to 250,000 pairs of random dots per second) and releases the microcomputer for duties such as controlling the size, position and sense (crossed/uncrossed) of the disparate region. The microcomputer has also been interfaced with a PDP-12 laboratory minicomputer. This machine is responsible for the acquisition of data, the averaging which is generally necessary to enhance a VER and also for off-line analysis of data.

ELECTROPHYSIOLOGICAL RECORDING

The equipment consists of an eight channel EEG unit which has been interfaced with the PDP-12. Seven channels are used monopolarly with a common linked mastoid reference. The seven scalp sites used are illustrated in Figure 2.

The three active midline sites are located at Oz, Pz and Cz (vertex) in the International 10-20 system. A pair of electrodes (Channels 4 and 5 respectively) lie over the angular gyrus region and its homologue in the right hemisphere and the remaining pair of electrodes (channels 6 and 7) lie midway between the angular gyral electrodes and Oz. The eighth channel is reserved for bipolar recording of eye movements.

A typical trial consists of up to 32 presentations of a stereoscopic stimulus. The averaging

program processes segments of EEG into an average; the length of each segment is predetermined, normally a half second in these trials, and each segment is time locked to the onset of the test stimulus. In this way the (random) noise components of the ongoing EEG activity are averaged out leaving behind

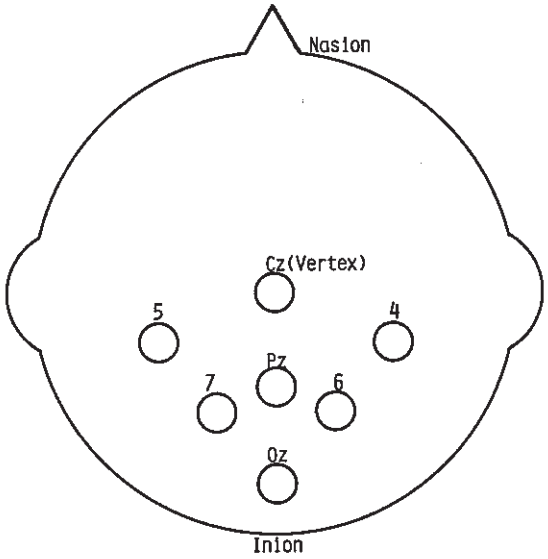

Figure 2: Location of the seven scalp electrodes. Electrodes 4 and 5 are sited over the angular gyrus. Electrodes 6 and 7 are located midway between the angular gyrus and Oz. A further pair of electrodes are used to monitor eye movements.

the evoked response signal. These VER averages are stored on tape for analysis and manipulation off line. The interstimulus interval can be set according to need, but in these trials it is normally either two seconds or a randomly changing interval in the range one to four seconds.

STEREOSCOPIC DISPLAY FORMAT

The random-dot test stimulus can take several forms. The most commonly used is a square stimulus in front of the background. When the display subtends approximately 10 degrees, the test stimulus subtends 3 degrees and is located either centrally or 3.5 degrees offset into left or right visual field. The disparity can be varied in steps of 150 sec. of arc (or 30 sec. of arc in the 2 degree field format), but has normally been set at 30 min. of arc to date. The subject views a red fixation light, usually in the centre of the display, and is presented with a plane background for a brief familiarization period. The disparate square then pulses on and off up to 32 times. The duration of presentation of the test square is typically 100 ms. An example of the VER of a normal subject to this stimulation sequence is seen in Figure 3.

USES OF THE STEREOSCOPIC VER

As the authors are still attempting to establish norms of performance for various age groups, it is too early to comment on the diagnostic effectiveness of the test. Nevertheless patients with visual defects do appear to give responses which differ from those of control subjects. This implies that it may be possible to use the

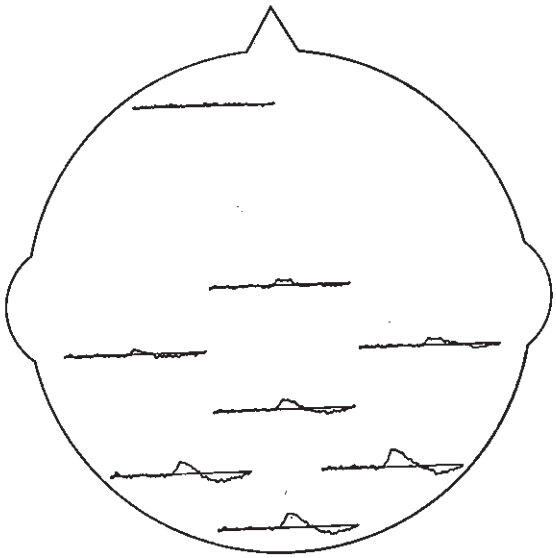

Figure 3: Visual evoked response of a control subject to a brief presentation of a central disparate region. Waveforms occupy a half-second. Onset occurred at 0.1s and offset occurred at 0.2s Interstimulus interval is approximately two seconds, n=64. Negative—UP.

equipment to achieve a detailed measure of the status of binocular vision. Figure 4 contrasts, at left, the evoked responses of control subjects, both of whom were visually normal, with at

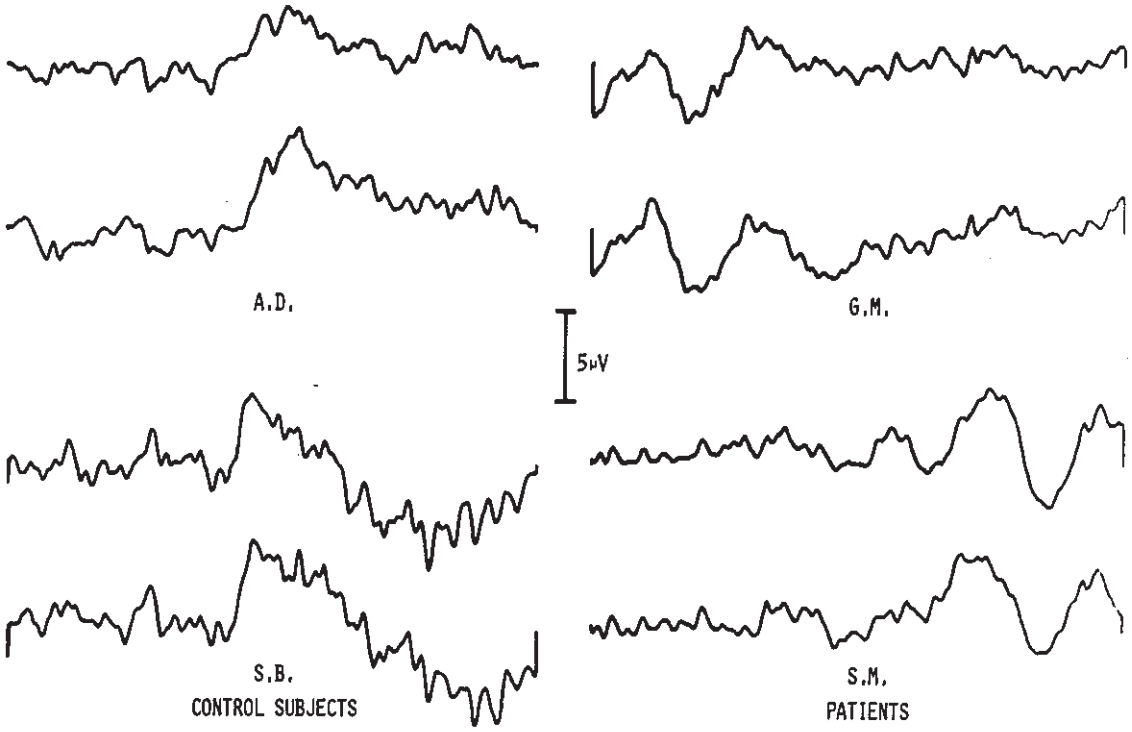

Figure 4: Visual evoked response of two control subjects, at left, and two patients, at right. For each subject the top trace is recorded from location 4 and the bottom trace from location 5. Recording and stimulus conditions are as for Figure 3.

right, the responses of two patients. All subjects are given a detailed screening test, including tests for visual acuity and ocular balance, traditional stereotests and the Stereo Wedge Test for stereoscopic vision.[15] The waveforms of Figure 4 occupy approximately 0.5 sec (512 ms) with onset of the stereoscopic stimulus at 0.1 seconds (100 ms) and offset at 0.2 seconds (200 ms). Interstimulus interval is about two seconds and each waveform is an average of 64 presentations. In this case the stimulus was presented in the central field. While the waveforms of the two control subjects are clearly not identical, they have common characteristics. For example there is a negative peak in the region 140 to 180 ms after stimulus onset followed by a positivity in the region 260 to 300 ms.

In comparison, the patient (G.M.) had an esotropia of very early onset. His eyes are now straight post-operatively and have equal visual acuity but he demonstrates no binocular function on routine orthoptic tests. This subject gave an abnormal response. While he had no subjective awareness of stereoscopic depth perception throughout these trials, the waveform indicates that there may be some limited residual binocularity. Preceding the onset of the stimulus is an apparently synchronised, alpha-like oscillation which is abolished shortly after onset. Possibly the brain is being activated by the stimulus. For this subject, it is difficult to detect an evoked response other than this activation. By contrast, patient S.M. at lower right is a child of better than average intelligence, slow reading speed and a mild grapho-motor problem.

Her visual status is good on routine tests: visual acuity R and L 6/5 with normal ocular muscle balance and good binocular function. However, reference eye tests show a very unsteady relationship of her reference eye to

her preferred right hand. Score on the Arden Gratings is several points better in the left eye than in the right eye.

For this subject the first negative peak occurs later than in the control subjects and the waveform terminates in an oscillatory build-up.

Further work is being done in an attempt to correlate visual status with the resulting visual evoked response.

CONCLUSIONS

Much work remains to be done if the evaluation of stereopsis using the VER is to take its place among standard clinical tests. It is the opinion of the authors that the methods and instrumentation touched on in this paper can be simplified and refined to a point where objective clinical evaluation of stereopsis using the VER can become a standard technique, at least for the larger clinics.

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