
Visually evoked cortical responses of amblyopes to a spatially alternating stimulus. SAMUEL SOKOL AND BENJAMIN BLOOM.

Early studies of cortical activity in amblyopia consisted of presenting subjects with the diffuse flashing lights of a photostimulator and measuring electroencephalographic (EEG) activity.1 In general, EEG irregularities were found when the amblyopic eye was stimulated but not when the normal eye was stimulated. More recent results obtained with flashing stimuli and computer averaging of sensory signals evoked from the occipital cortex have been inconclusive. Some investigators report that the computer-derived signal from the amblyopic eye showed amplitude and latency irregularities12 while others found no difference in the cortical signals evoked by the normal and amblyopic eyes.5, 7

Most recently, a checkerboard-patterned stimulus has been used to elicit visually evoked cortical potentials (VECP). While considerable attention has been given to the use of checkerboard-patterned stimuli in the study of the VECP in subjects with normal vision8 and as a technique for determining refractive errors9 there have been few reports where patterned stimuli have been used to study the VECP of amblyopes. Lombroso, Duffy, and Robb10 report that with a patterned stimulus, 50 per cent of their subjects elicited a smaller amplitude VECP when the amblyopic eye was stimulated. The patterned stimulus used in this study, however, was a checkerboard transparent screen back illuminated with a photostimulator. Use of this type of stimulus results in a "transient" VECP containing two components: a spatial component elicited by the pattern contours and a luminance component elicited by the change in luminous flux of the photostimulator as it flashes on and off behind the transparencies.11 As a result, when there is a decline in the spatially generated signals, a large luminance component is still present. The patterned stimulus used in the present study consisted of a phase reversal of the checks which results in the total luminous flux remaining nearly constant. With this type of stimulus display any contribution of luminance to the VECP is eliminated and the amplitude of the "steady state" VECP will approach zero as the ability of the visual system to resolve the spatially alternating stimulus decreases.

The spatially alternating stimulus used in the present experiment is described in detail elsewhere.12 Essentially, the retina is being stimulated by a pattern whose elements are changing their luminance relative to each other but whose total luminous flux remains nearly constant. Subjects sat 75 cm. from the stimulus with the aid of a chin rest. At this distance the entire checkerboard array subtended a square field of 18°. An 18° field was used to insure that subjects with eccentric fixation would still receive foveal stimulation. The total mean luminance of the stimulus was 50 ft. lamberts as measured with a S.E.I. photometer. The rate of stimulus alternation was 12 Hz.

VECP's were recorded using two electrodes located along the midline; the first electrode was 2 cm. above the inion, the second electrode was 6 cm. above the first. The ear served as a ground. Electrode leads were connected to a wide-band EEG preamplifier with low frequency cut-off at 1 Hz. and to a DC driver amplifier with high-frequency cut-off at 35 Hz. Responses were then led to an FM tape recorder and a signal averager.

VECP's were recorded from 15 amblyopic subjects ranging in age from 5 to 63 years. Only two of the subjects were older than 12; one was 25 years of age, the other 63 years of age. Seven subjects had a strabismus, two subjects were anisometropic, and 6 subjects had a strabismus and anisometropia. All subjects exhibited some degree of eccentric fixation. Subject J had an unsteady nasal fixation of 3° and the remaining subjects had eccentric fixation of no greater than 1°. All of the subjects received a complete eye evaluation and those under 12 years of age were given a cycloplegic refraction. During the recording session each subject used the optical correction determined from his previous refraction.

Each eye was tested alone. The subject was instructed to fixate on a small red spot in the center of the checkerboard pattern. No mydriatics or cycloplegics were used during the recording of the VECP's. All subjects were tested with checks that subtended a visual arc of 15°. In addition, four of the subjects were tested on two separate occasions using 15° checks and one of the subjects was tested on two occasions with checks which
Fig. 1. VECP records obtained with stimulation of normal and ambylopic eyes of 6 subjects. Each pair of records represents data from one subject. The VECP obtained from stimulation of the normal eye is shown above and from the ambylopic eye is shown below. Table I contains specific details on each subject.

Fig. 2 shows the VECP amplitude (μV) for Subject S with different size checks. Subject S was tested on two occasions separated by a period of 8 months. No change in her ocular status or VECP results occurred during this period. These data show that when the normal eye is stimulated the maximum VECP amplitude is elicited with 15' checks. When the ambylopic eye is stimulated the maximum amplitude of VECP response occurs with 60' checks.

These results agree in general with the previous work of Lombroso, Duffy, and Robb. They reported that while all of their ambylopic subjects showed a reduction in waveform complexity in the ambylopic eye, only 50 per cent of their subjects showed an amplitude reduction. We find that with a spatially alternating checkerboard stimulus all of our subjects exhibit a reduction of VECP amplitude with stimulation of the ambylopic eye and the acuity reduction between the normal and ambylopic eye. For example, Subjects N and I both showed a 43 per cent amplitude reduction in their ambylopic eyes but their acuities were 20/70 and 20/200, respectively.

Peak to trough amplitudes were measured for each series of waves and the median values determined. The per cent VECP amplitude reduction of the ambylopic eye was then calculated for each subject. Table I shows the data obtained for all subjects. We find in all subjects tested that the amplitude of the VECP recorded when the ambylopic eye is stimulated is smaller than the amplitude of the VECP obtained when the nonamblyopic (normal) eye is stimulated. Even though there is a consistent amplitude reduction in the ambylopic eye, no significant relationship was found between per cent reduction of VECP amplitude in the ambylopic eye and the acuity reduction between the normal and ambylopic eye. For example, Subjects N and I both showed a 43 per cent amplitude reduction in their ambylopic eyes but their acuities were 20/70 and 20/200, respectively.
Table 1. Diagnosis, visual acuity (line and single letter) for the amblyopic eye, and per cent reduction of VECP amplitude in amblyopic eye for all subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Diagnosis</th>
<th>Line acuity</th>
<th>Sep. E</th>
<th>Per cent reduction</th>
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<tbody>
<tr>
<td>F(1)*</td>
<td>M,S,A</td>
<td>20/70</td>
<td>20/70</td>
<td>28</td>
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<tr>
<td>F(2)</td>
<td>—</td>
<td>20/70</td>
<td>20/50</td>
<td>23</td>
</tr>
<tr>
<td>R(1)</td>
<td>H,S,A</td>
<td>20/70</td>
<td>20/50</td>
<td>6</td>
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<tr>
<td>R(2)</td>
<td>—</td>
<td>20/70</td>
<td>20/50</td>
<td>65</td>
</tr>
<tr>
<td>J(1)</td>
<td>H,S</td>
<td>20/100</td>
<td>20/50</td>
<td>6</td>
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<tr>
<td>J(2)</td>
<td>—</td>
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<td>20/50</td>
<td>40</td>
</tr>
<tr>
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<tr>
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<td>15</td>
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<td>20/40</td>
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<tr>
<td>I</td>
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<td>M,S,A</td>
<td>10/200</td>
<td>20/50</td>
<td>100</td>
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</table>

Note: Line acuity for nonamblyopic eye was 20/30 or better in our subjects. Subject D had cosmetic strabismus surgery between the first and second test sessions.

*Subscript 1 and 2 represents data for those subjects who were tested twice.

1M (myopia), H (hypermetropia), A (anisometropia), S (strabismus).

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Fig. 2. VECP amplitudes of Subject S as a function of check size. Closed circles: normal eye. Open circles: amblyopic eye.

amblyopic eye. This discrepancy may be explained by the fact that the check size used by Lombroso, Duffy, and Robb10 was approximately 60' while the check size used in the present study subtended a visual angle of 15'. A check size of between 10' and 20' has been shown to elicit the largest amplitude VECP in an emmetrope14 and more of the amblyopes tested by Lombroso, Duffy, and Robb10 may have shown amplitude differences between eyes if smaller checks had been used. With smaller checks one would expect larger amplitude VECP's with stimulation of the normal eye and as a result a difference in amplitude between the normal and amblyopic eye.

Like Lombroso, Duffy, and Robb10 we found no relationship between acuity reduction and VECP amplitude reduction with 15' checks. However, when Subject S was presented with different size checks there was a clear difference in the point of maximum VECP amplitude between eyes. The maximum VECP amplitude was elicited by stimulation of the normal eye with 15' checks while the maximum VECP amplitude of the ambylopic eye occurred with 60' checks. Harter and White11 have shown that an emmetrope will elicit maximum VECP amplitude with 10' to 20' checks, but that when a refractive error is induced with spherical lenses the maximum VECP amplitude will occur with larger size checks. They found that when at least 3 diopters of refractive error is present and the surface-positive component of the VECP is measured, the maximum VECP amplitude occurs with 60' checks. Further, we find that an emmetrope's visual acuity is reduced to approximately 20/200 with a 3 diopter convex lens. This correlates with the results of Subject S whose visual acuity was 20/200 and who showed a maximum VECP amplitude at 60'. While we find the results for Subject S are reproducible even after a period of 8 months we are presently testing other amblyopes under conditions of different check size to determine if the point of their maximum VECP amplitudes reflects the subjective acuity of their normal and amblyopic eyes.

The back-illuminated and the spatially alternating checkerboard are no doubt both effective stimuli for studying amblyopia at the cortical level. Although each stimulus evokes a different type of cortical activity11 a thorough examination of both "steady state" and "transient" cortical potentials in relation to amblyopia is needed. However, if one is interested in recording the electroretinogram (ERG) of an amblyope it should be done with a spatially alternating stimulus,12, 15 and second, it would be virtually impossible to record cone-elicited ERG's with a back-illuminated checkerboard since large amounts of scatter would be present and a large rod contribution to the ERG would occur.16 While previous reports13, 17 have
indicated that the ERG is normal in amblyopia; these studies have used only flashing lights and a large rod contribution may have masked the cone signals.

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Key words: amblyopia, visual cortex, evoked potential, patterned stimuli, electroretinogram, checkerboard stimuli.

REFERENCES


The release of PGE₂-like activity into aqueous humor after paracentesis and its prevention by aspirin. J. D. MILLER, K. E. EAKINS, AND M. ATWAL.

Recent evidence suggests that prostaglandins (PG’s) are involved in ocular inflammation. PG-like substances are present in ocular tissues and low concentrations applied intracameral or topically to the eye can induce many of the characteristic changes associated with ocular inflammation. More recently, PG-like activity has been detected in aqueous humor from rabbits with experimentally induced uveitis and from patients with acute, untreated anterior uveitis.

Indomethacin, aspirin, and other nonsteroidal anti-inflammatory agents have been found to inhibit PG-biosynthesis in various tissues and Vane has proposed that this effect is the basis of their anti-inflammatory, antipyretic, and analgesic actions. Aspirin has recently been used experimentally in rabbits to block the effects of acute trauma in the eye, but no correlation with PG-levels or PG biosynthesis has been made. The present study was undertaken to further clarify the role of the PG system in acute ocular trauma, specifically paracentesis.

New Zealand white rabbits of either sex (2.5 to 3 kilograms) were lightly anesthetized with intravenous sodium pentobarbital, aspirin (600 mg per animal) was administered rectally to 15 animals and the anesthesia was maintained throughout the experiment. Supplemental injections were made as required to maintain a stable level of anesthesia. Control rabbits maintained under anesthesia for the same period of time did