Electroretinograms from noncorneal electrodes

Donald I. Tepas and John C. Armington

Averaged potentials picked up by electrodes placed near the canthi of the eye have a waveform similar to the electroretinogram recorded simultaneously with a contact lens. The findings indicate that a representative electroretinogram can be obtained from noncorneal electrodes over a wide range of stimulus conditions when averaging techniques are applied.

Although it has long been known that retinal action currents are present, the electroretinogram (ERG) has not become the subject of detailed investigation in the human until recent years. Before Riggs demonstrated that the response might be easily recorded from an electrode supported by a contact lens, no satisfactory method for continuous recording from the human was available. This technique has greatly facilitated research, but use of a contact lens electrode limits the maximum length of experimental session possible and may, in some cases, restrict the properties of the visual task to be observed and measured. In addition, not all individuals find the lens to be comfortable, and this may also increase recording difficulty.

Motokawa and Mita reported that the ERG could be recorded from a pair of noncorneal electrodes, one attached to the bridge of the nose and the other attached to the temple near the eye being investigated. This method has not been widely used since the small signals it provides are usually well masked by bioelectric artifacts. The present report shows that ERG's of low amplitude may be readily detected with noncorneal electrodes if a computer is used to average the potentials which follow repetitive photopic stimulation.

Methods

The apparatus used for stimulation of the eye and for recording has been described more fully elsewhere. The stimulator used presented the subject with a Maxwellian view of flickering stimuli. Colored stimuli were obtained by placing a Corning red filter No. 2418 or blue filter No. 5543 in the light path. Luminance was varied with Wratten neutral density filters. The stimuli flickered at a rate of five flashes per second and with a flash duration of 0.04 second.

The potentials from three channels were simultaneously amplified and then recorded, together with a stimulus marker, on magnetic tape. On one channel, the potentials arising between a contact lens electrode and a reference electrode on the chin were recorded. On a second channel, activity arising between an electrode attached to the skin just below the brow, but above the eyelid, and a reference on the chin were recorded. The third channel recorded activity picked up by a pair of electrodes mounted about one quarter of an inch from the external and internal canthi of the eye. The tape recording, thus obtained, was played into a special-purpose analog computer which averaged the activity that followed the recurrent stimuli. Subjects were dark adapted for 30 minutes prior to recording.

Results

Two subjects were used, and the data from both subjects are similar in all major
Electroretinograms from noncorneal electrodes

respects. The results obtained from one subject in response to red stimulation are summarized in Fig. 1. The insert in the right-hand graph shows the response waveforms picked up by the contact lens channel (lens) and the channel obtained from the electrodes near the canthi (remote). The lens response waveform shows a corneal negative (downward) A deflection followed by a double positive wave. The potentials were larger when strong stimuli were used. The waveform obtained from the remote electrodes was similar to that obtained from the lens channel except that it was of considerably lower amplitude. The deflection was downward when the temporal electrode was positive with respect to the nasal electrode. The waveforms obtained from the brow-chin recordings are not shown inasmuch as they were irregular and did not always resemble either the lens or the remote waveforms.

The over-all, peak-to-peak excursion of the deflections obtained from all three channels was measured. The relation between this measure and stimulus luminance for the lens channel and the remote channel is shown on the left in Fig. 1. It is clear that the waves recorded from both channels increased in a regular and fairly proportionate manner as the density of the filters in the light path was reduced. Measures of the potentials picked up with the brow-chin electrodes showed a much more complex relation to stimulus luminance and are not plotted. The distance between the lowest point in the A wave and the highest point of the first positive wave was measured for the lens and remote channels. The relation between these measures and stimulus luminance is shown on the right in Fig. 1. Again, the waves recorded from both channels increased in a regular manner as stimulus luminance was increased.

The results obtained with blue stimulation are not shown. In general, blue stimulation produced an initial negative A wave followed by a positive B deflection. This

---

**Fig. 1.** Relations between amplitude of response and stimulus luminance with 5-per-second red flicker.
waveform could be seen in both the lens and remote channels. The potentials from the lens channel were again much larger than those of the remote channel. Similarly, the amplitudes of the blue potentials seen in the lens and remote channels showed a proportionate increase with test luminance for both subjects. The potentials picked up by the brow-chin electrodes could not be readily related to the lens potentials.

Discussion

The results suggest that averaging may be used to record the ERG from electrodes which are not mounted directly upon the eye, but are merely close to it. The waveform obtained is similar, but not identical, to that found with a contact lens. The importance of electrode placement does appear to be quite relevant. Potentials picked up by the remote temporal-nasal placement appeared to be much more favorable than those obtained from the brow-chin placement, not because no potentials were seen, but because of their complex nature. The relation of brow-chin waveforms to stimulus luminance suggested that the potentials from this placement are often dominated by evoked potentials of the brain.

The data support the findings of Motokawa, Dzendolet, Rémont, and others whose data suggested that the ERG might be obtained with remote electrodes. The technique is much less sensitive than the conventional one using the contact lens electrode, and it is not likely to supplant it under most circumstances. It may be of considerable value, however, in studying the responses of children and other individuals who experience difficulties with contact lenses.

REFERENCES