EARLY RECEPTOR POTENTIAL IN THE HUMAN EYE*†

BY

N. R. GALLOWAY

Institute of Ophthalmology, University of London

BROWN and MURAKAMI (1964) published a report on a new receptor potential obtained by using intraretinal micro-electrodes and intense stimulus flashes. Shortly afterwards Cone (1964) demonstrated that this potential could be observed as a component of the corneal electroretinogram (ERG). It is now known as the early receptor potential (ERP) and occurs after a very short latent period (less than 60 μ sec.); it is composed of a small positive peak followed by a larger negative one. The *a* wave component of the ERG, which follows immediately after the negative peak, is the leading edge of the process now called the late receptor potential. Cone found that the ERP was present in a wide variety of vertebrate eyes.

Because of its short latency, the ERP must be the electrical representation of one of the first processes to occur when light strikes the retina. Cone has shown that in the albino rat it has the same spectral sensitivity as the dark-adapted *b* wave and that the amplitude of the ERP is proportional to the amount of rhodopsin bleached by a flash. However, the role of the ERP in producing a visual sensation is unknown. With suitable apparatus it can be evoked relatively easily and rapidly in man and hence may prove a useful tool for clinical research and diagnosis.

There are four points to remember in trying to record an ERP:

(a) The stimulus must be a brief intense flash; a recordable ERP is not produced unless the light is spread over a wide area of the retina.

(b) A large electrical artefact may be produced by the stimulus light and power pack; these must be kept as far as is practicable from the subject and must be well screened.

(c) If the stimulus light falls on metal electrodes, a photovoltaic artefact will appear which resembles an ERP; this can be eliminated by optical screening and the use of malleable stainless steel electrodes.

(d) The short duration of the response makes it impossible to record it on ordinary pen writers and an oscilloscope must be used.

Apparatus

The stimulus light was an ordinary Xenon photographic flash tube (45 Joules), screened with metal sheeting on five sides (an incomplete box), and mounted at the end of a brass tube about 3 feet long and 5 inches in diameter. The tube contained a lens system enabling light from the stimulus to be focused on the subject's pupil. A small red fixation light was placed in the optical path so that the subject could align himself in relation to the

* Received for publication September 9, 1965.

† Address for reprints: Moorfields Eye Hospital, High Holborn, London, W.C.1.

stimulus flash. The fixation light was bright enough to enable the operator to check the alignment of the subject by locating the red image on the pupil. The strength of the stimulus flash was 12 log units above the dark-adapted threshold.

The potential was recorded between a contact lens electrode (Fig. 1) and two silver skin electrodes secured on cheek and forehead. The contact lens electrode had a side tube onto which a polythene tube was fitted. By injecting normal saline down this tube, air bubbles could be expelled from the space between lens and cornea. A piece of malleable stainless steel wire passed through the wall of the side tube of the contact lens, being bathed in saline within the tube; it was therefore in electrical contact but not physical contact with the cornea. The side tube and periphery of the contact lens were blackened. The skin electrodes were the standard silver ones used for electroretinography; they were filled with electrode jelly and secured with black masking tape.

FIG. 1.—Diagram of contact lens electrode.

From these electrodes the input was fed into the differential amplifier of a 'Tectronix 502A' oscilloscope. The responses were photographed with a polaroid camera mounted on the oscilloscope face. The external trigger circuit shown in Fig. 2 is simple and inexpensive; the relay is not a high speed one and its use eliminates the necessity for complex timing-gear.

FIG. 2.—External trigger unit.

The absence of a light artefact could be shown by immersing the skin electrodes and contact lens in saline and exposing the contact lens to the stimulus flash. The absence of an electrical artefact could be shown by placing an opaque screen in front of the flash when the contact lens was in the eye.

Results

Fig. 3 shows the type of response produced by this method. In Fig. 3(a), the upper trace is the type of response obtained with a background of normal room lighting and with no previous dark adaptation, and the lower trace shows the result of repeating the flash one minute later. In both traces, the ERP, followed by the *a* wave and then the oscillatory potential of the *b* wave, can be seen. The size of the second response is considerably reduced. In Fig. 3(b), the upper trace shows a response obtained after 20 minutes of dark adaptation. The ERP is about the same size as that obtained without previous dark adaptation, but the *b* wave is larger. A second flash 30 seconds later produced the lower trace in which the ERP is very small, and the *a* wave and *b* wave are almost abolished.

FIG. 3 (a).—Upper Trace: Single flash with eye adapted to room lighting. Lower Trace: Second flash one minute later.

FIG. 3 (b).—Upper Trace: Single flash after 20 minutes dark adaptation. Lower Trace: Single flash 30 seconds later, showing very small ERP.

It will be seen that the oscillatory potential of the *b* wave shows up clearly when produced by this method (Cobb and Morton, 1954).

Fig. 4 shows the ERP of a patient with advanced retinitis pigmentosa who had a

FIG. 4.—Upper Trace: Case of retinitis pigmentosa, ERP first flash. Lower Trace: Same case, second flash one minute later.

visual acuity of 6/60, a typical history and fundus appearance, and grossly constricted visual fields. The first flash produced a very small ERP, and the second flash, one minute later, produced no response.

Discussion

It is interesting to compare these results with those of Hirose and Yonemura (1965) who have used a Xenon flash to elicit the ERG; although a special lens system was not used and the electrodes were not screened, there does appear to be a small ERP on some of their traces.

The method described here provides a way of investigating the ERP which can be easily performed in the clinic. It has the following advantages over many other electrodiagnostic tests of visual function:

(a) It is a measure of the integrity of the outer limbs of the receptors which is independent of other neural events. It may therefore be of value in providing a differential diagnosis for pathological conditions affecting the peripheral structures of the visual system.

(b) It gives more information of the amount of visual pigment present in the eye than the ERG because it does not rely on the integrity of neural amplifiers.

(c) Dark adaptation is unnecessary, because in normal room lighting the amount of rhodopsin in the retina is nearly the same as in the dark-adapted eye. The test is therefore rapid and the contact lens need be worn for only a short time. This makes the test more comfortable for the patient and minimizes the risk of corneal damage.

The most rapid results can be obtained if the pupils of the patient are already dilated on arrival.

Summary

A method is described of eliciting the early receptor potential in man. The ERP is a component of the electroretinogram which has been recently identified. The method is suitable for use in the electrodiagnostic clinic.

I should like to thank Dr. G. Arden for his invaluable help and Miss J. Berman for her assistance in obtaining the recordings. I am also indebted to Mr. Frederick Ridley for his helpful advice on the design of the contact lens and to Mr. T. Tarrant for preparing the illustrations.

REFERENCES

- BROWN, K. T., and MURAKAMI, M. (1964). *Nature (Lond.)*, **201**, 626.
 COBB, W. A., and MORTON, H. B. (1954). *J. Physiol. (Lond.)*, **123**, 36P.
 CONE, R. A. (1964). *Nature (Lond.)*, **204**, 736.
 HIROSE, T., and YONEMURA, D. (1965). "ERG in Takayasu's Disease", News Letter of the International Society for Clinical Electrophysiology, vol. 6, No. 1. ISCERG, Rotterdam, Netherlands.