Electroencephalogram Potentials Evoked by Hemi-Retinal Stimulation

Electrophysiological localization for visual stimulation has been studied in the normal human cortex by means of averaged evoked potentials. These were recorded at the scalp in response to half-field visual stimulation.

Apparatus. A one meter diameter hemisphere provided high luminance white light adaptation at a level of 100 ft-L to reduce the effects of stray light exciting non-adapted retina or cortex. An aperture at the center of the hemisphere admitted light from a xenon flash lamp and reflector (Grass photic stimulator). Back of the aperture was a red glass filter (Corning 2412) and a diffusing ground glass both in front of the flash lamp. The subject was positioned at the center of the hemisphere with a head and chin rest 50 cm from the stimulus light.

Standard EEG electrodes (5 mm diameter) of the chlorided silver type were attached to the scalp with electrode cream following the International 10–20 EEG system with additions[1]. Monopolar recording was used with linked ear lobes as the common reference. Amplification was by differential a–c amplifiers feeding into a digital signal averager (Fabri-Tek).

Procedures. For all data collection, one half of the aperture in the adaptation hemisphere was occluded with a white cardboard mask. Thus the xenon flash stimulus was presented to the subject as a half disc 15° vertical by 7.5° horizontal extending to the right or left in his visual field. Stimulation consisted of the red stimulus light flashing at a rate of 3.3 H_z for a summation of 256 flashes. Photic stimulator intensity was maintained at a constant level (1-4). Monocular stimulation was used with the other eye covered by an opaque black eye patch. The subject was directed to fixate the center of the vertical edge of the stimulus.

For an eye movement control, electroculogram (EOG) electrodes were attached to the skin near the nasal and temporal corners of the stimulated eye. The resulting EOG potentials were averaged at the same time as the cortical potentials were recorded. For an EEG reference control, some experimental sessions were conducted with the active monopolar electrodes positioned as usual, but with the reference electrode positioned on the midline either at the chin or forehead.

Results and discussion. Figure 1 illustrates electrophysiological localization achieved under these conditions. Electrode positions P_3 and T_5 were located over the left cortical hemisphere while P_4 and T_6 were over the right. The solid line represents the evoked potential resulting from stimulation of the right visual field. The component labeled P_{1a} is larger over the left hemisphere than over the right. The evoked potential resulting from stimulation of the left visual field is represented by the dotted line. In this case, the P_{1a} component is larger over the right hemisphere than over the left (component labels similar to VAUGHAN)[2]. This contrast between the responses of the 2 cerebral hemispheres to stimulation of the 2 halves of the visual field is consistent with the anatomy of the visual pathways. The lateral half of each visual field projects to the contralateral cerebral hemisphere.

Evoked potentials have been recorded in response to eye movements with a non-flickering stimulus[3]. The results of the control procedures in the present experiment, however, showed that lateral eye movements were not the cause of these differing cortical potentials. EOG recordings were essentially flat, indicating no eye movements were synchronized with the flickering stimulus light. The results of the control procedures also showed that the differing evoked potentials were not artifacts of reference electrode position. In spite of increased biological noise from the midline positions, essentially the same results were found in response to half-field stimulation as when using linked earlobes as the reference.

More detailed representation of the locus of these evoked potentials was provided from 17 electrode positions. 9 channels were recorded simultaneously (4 on line, 5 on FM tape), and a second 9 were recorded subsequently. The resulting potential distributions are shown in Figure 2 on a posterior view of the scalp. Stimulating the right half-field produced a positive P_{1a} peak over the left hemisphere near P_3 with an apparent negative maximum at a lower position over the right hemisphere. Conversely, stimulating the left half-field produced a positive P_{1a} peak over the right hemisphere near P_4 with a small negative peak over the left hemisphere. The axis of the voltage distribution is not generally horizontal, but may show different angles of tilt for different subjects. Similar potential distributions are found for either right or left eyes in the same subject.

This differentiation of P_{1a} amplitude between the 2 hemispheres as a function of which lateral half-field was stimulated has been found in 6 subjects tested. For 1 subject, P_{1a} consisted of 2 sub-peaks, but its amplitude showed the same localization over the 2 hemispheres as was found for the other subjects. Latencies for the P_{1a} peak varied among subjects from 63 to 74 msec with a mean of 68 msec. In some subjects, other early EP components have also shown hemisphere differences related to lateral visual stimulation, such as the negative com-

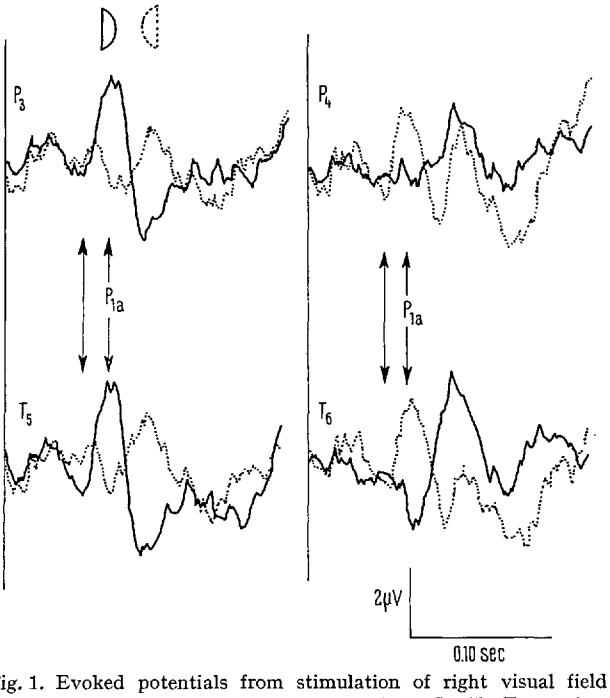

Fig. 1. Evoked potentials from stimulation of right visual field (solid line) and left visual field (dotted line). P_3, P_4, T_5, T_6 are electrode positions. A positive potential at the labeled electrode is upward. Amplitudes of component P_{1a} were measured vertically between the latencies marked by the arrows.

[1] H. H. JASPER, Electroenceph. clin. Neurophysiol. *10*, 371 (1958).
[2] H. G. VAUGHAN JR., Vision Res., Suppl. *6*, 203 (1966).
[3] K. GAARDER, J. KRAUSKOPF, V. GRAF, W. KROPFL and J. C. ARMINGTON, Science *146*, 1481 (1964).

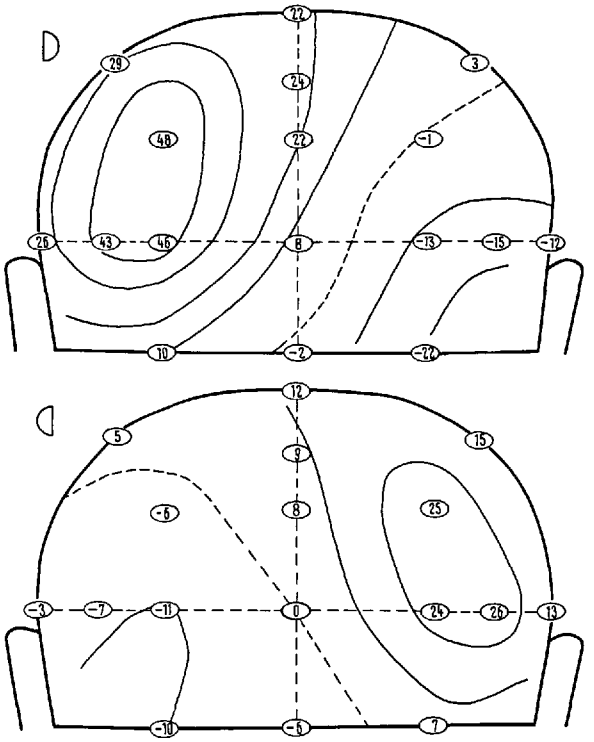

Fig. 2. Posterior scalp view of the P_{1a} potential distributions from stimulation of the right visual field (upper plot) or left visual field (lower). Electrode location at the bottom midline is the inion. Moving forward are electrodes at 10% distance (O_z), 20%, 30% (P_z), and 50% (C_z). Moving left horizontally from O_z are electrodes at 15% distance, 30% (T_5), and 50% (T_3). Also shown in the upper left quadrants are electrodes P_3 and C_3. Directly below the first electrode to the left of O_z is one on line horizontally with the inion. Similar positions are recorded on the right hemisphere (even-numbered). Potentials are microvolts × 10.

ponent preceding P_{1a} or the negative component following P_{1a}. The preceding negative component is very small, however, and difficult to measure reliably in the present averages.

Clinical studies on hemianopic patients support the interpretation that these localized evoked potentials result from stimulation of visual half-fields[2,4,5]. Research is continuing on the contour mapping of these potential distributions, and to determine the possible cortical sources for these potentials.

Conclusions. We conclude that under photopic experimental conditions it is possible in normal subjects to achieve sharply differentiated evoked potentials over the 2 cerebral hemispheres with lateral half-field stimulation. This finding has implications both for the understanding of normal visual brain functioning and for the clinical problem of hemianopia[6].

Zusammenfassung. Als Reaktion auf Reizung der lateralen Gesichtsfeldhälfte wurden evozierte Potentiale der Hirnrinde des Menschen registriert. Reizung der einen Gesichtshälfte erzeugte frühzeitig ein Maximum der Potentiale der gegenseitigen Hemisphäre sowie Phasenumkehr der Potentiale der gleichseitigen Hemisphäre.

W. R. Biersdorf and Z. Nakamura

Department of Ophthalmology, and
Institute for Research in Vision, Ohio State University, Columbus (Ohio 43212, USA), 5 October 1970.

[4] K. A. Kooi, A. M. Güvener and B. K. Bagchi, Neurology *15*, 841 (1965).
[5] D. Regan and J. R. Heron, J. Neurol. Neurosurg. Psychiat. *32*, 479 (1969).
[6] Supported in part by U.S. Public Health Service grant No. EY00454. The authors wish to thank William Bell for technical assistance.

Photolysis and Birefringence of Frog Rods

When an action potential is transmitted through nerve fibres they exhibit an almost synchronous change in birefringence[1]. It is, therefore, of interest to inquire whether photoreceptors may not also manifest changes in birefringence following the absorption of light.

The effect of light on the properties of frog rods[2] can be studied in more detail with spectral lights if the time-course of events is tracked than was done in Schmidt's pioneering study[3]. 3 distinct processes can be distinguished and related to the photolysis of rhodopsin if the photometric density of the material is studied under similar conditions.

Single dark-adapted frog rods were examined with a polarizing microscope. Their nominal retardance was measured with a Brace-Köhler compensator by the method of Bear and Schmitt[4]. The densitometric data were obtained by passing light through a small number of randomly orientated rods, collecting it on a photoelectron multiplier and displaying the resultant photocurrent on a cathode-ray oscillograph. Data from 3 experiments are shown by the open symbols in the Figure. The measuring and bleaching lights were the same, $\lambda = 506$ nm, and the intensity equalled $3.03 \times 10^{18}\, q_{506}/m^2/s$. These data follow an exponential (half-time = 16 sec).

If the monochromatic light used in the polarizing microscope is absorbed by rhodopsin then the nominal retardance measures essentially the dichroism due to the orientation of the unbleached rhodopsin molecules[3,5]. But this is impossible with light of long wavelengths, which are not appreciably absorbed by rhodopsin. The filled circles in the Figure show average results for the retardance (per unit path-length) measured with $\lambda = 589$ nm and $\lambda = 620$ nm. The active light was the same as that used in the densitometric data, namely $\lambda = 506$ nm. Similar sets of data can be obtained with measuring lights of $\lambda = 567$ nm and even $\lambda = 506$ nm if a correction is applied for the contribution due to dichroism.

The results shown with the filled circles may hence represent a change in the birefringence of the rod: they follow an exponential (half-time = 46 sec); the final value (B_w) for the bleached material lies within the

[1] L. B. Cohen, R. D. Keynes and B. Hille, Nature, Lond. *218*, 438 (1968).
[2] R. A. Weale, J. Physiol., Lond. *204*, 123P (1969).
[3] W. J. Schmidt, Pubbl. Staz. zool. Napoli *23*, 158 (1951).
[4] R. S. Bear and F. O. Schmitt, J. opt. Soc. Am. *26*, 363 (1936).
[5] E. J. Denton, Proc. R. Soc. B. *150*, 78 (1959).