XI. COMMUNICATIONS BIOPHYSICS

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A. CHANGES IN CORTICAL CLICK RESPONSES AS A FUNCTION OF CLICK INTENSITY AND DEPTH OF ANESTHESIA

In the Quarterly Progress Report, April 15, 1955, pp. 76-77, we noted a relation between a measure of summed cortical on-going activity immediately preceding the click-evoked responses and the size of the individual click responses.

In the present study, we have examined the changes in amplitude and variability of amplitude of the cortical click response in anesthetized cats as a function of click intensity and depth of anesthesia.

Figure XI-1a indicates the location of our "active" electrode in the middle ectosylvian gyrus. Figure XI-1b illustrates a typical click response from this cortical point together with the amplitudes we have measured. The data presented below are for the peak-to-peak amplitude a_2.

Responses to fifty clicks presented at a rate of one every four seconds were recorded for each of five click intensities at each of four levels of anesthesia. The intensity levels were separated by 20-db steps from 10 db to 90 db re the cat's click threshold. During each set of five intensities, the anesthesia level was kept as constant as possible by continually checking the electrocorticogram (ECG) and injecting Dial whenever necessary (see Fig. XI-2). For each intensity-anesthesia condition the mean amplitude and the standard deviation were computed for fifty responses. The results

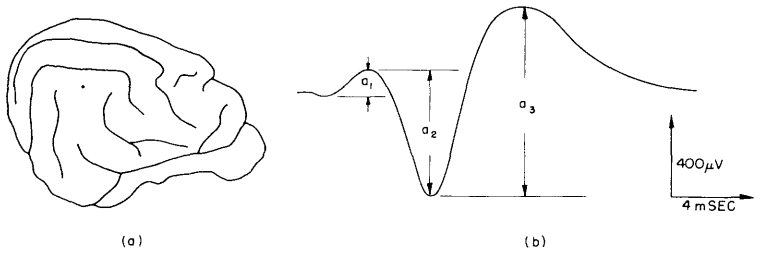

Fig. XI-1. a. The cat brain. The active electrode was placed in the middle ectosylvian gyrus in the location indicated by the dot; b. A typical electrical response evoked by click (upward deflection indicates negative polarity at the active electrode). Of the amplitudes a_1, a_2, and a_3, only the a_2 measurement was used in this study.

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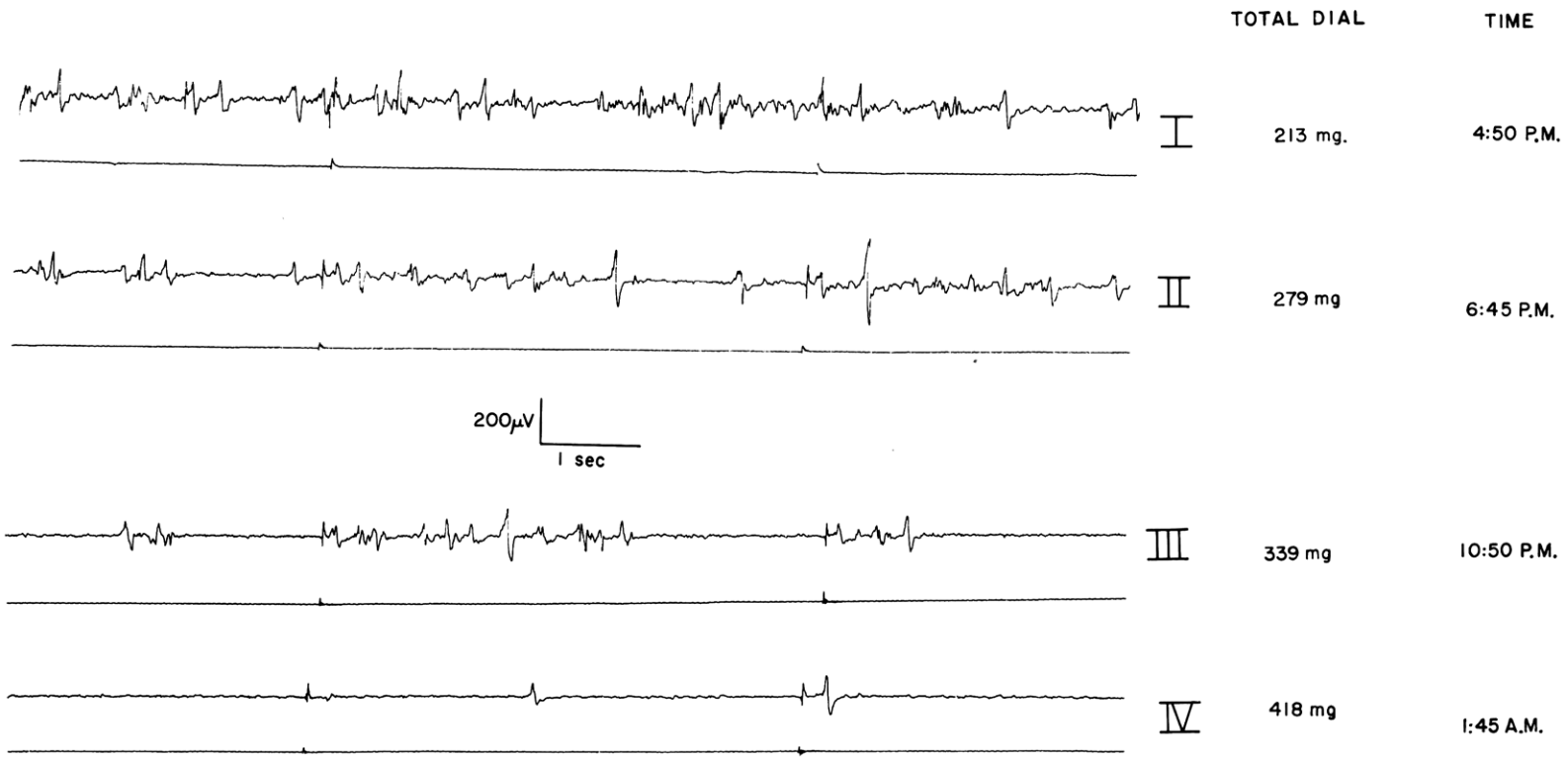

Fig. XI-2. The four (I, II, III, IV) ECG records were taken during actual presentation of clicks at each of the anesthetic levels in order of increasing depth. The markers under each ECG indicate the presentation of a click. Dial was initially given intra-peritoneally (IP) although subsequent doses were given intravenously (IV). The times show when each record was taken.

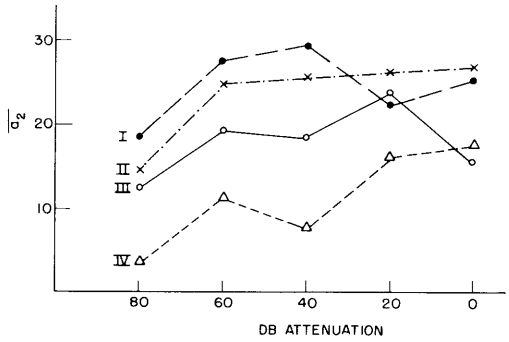

Fig. XI-3. The mean amplitudes of groups of 50 consecutive responses are plotted against click intensity for each level of anesthesia (I, II, III, IV) corresponding to those of Fig. XI-2. The response amplitudes are in arbitrary units.

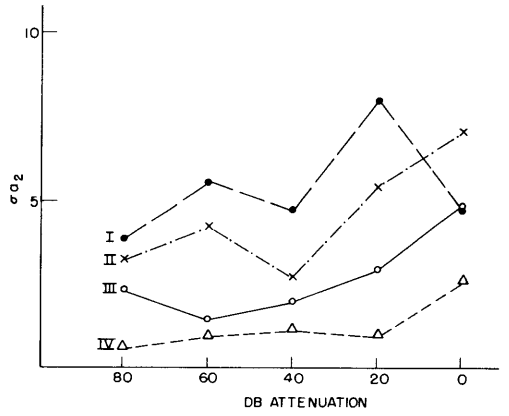

Fig. XI-4. The standard deviation (σa_2) of the same groups of fifty responses for which the mean amplitudes were plotted in Fig. XI-3 are here plotted against click intensity for the same parametric values of anesthesia.

are summarized in Figs. XI-3 and XI-4.

In general, both the mean response amplitude and the standard deviation increase with click intensity and decrease as the level of anesthesia is deepened.

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B. AN ELECTRONIC DEVICE FOR THE DETECTION OF EVOKED RESPONSES IN POTENTIALS RECORDED FROM THE SKULL

The amplitude of on-going electrical activity recorded from the brain of awake subjects is large compared to the activity evoked by sensory stimuli. It is then difficult to detect the evoked activity in the EEG; frequency characteristics of present inkwriters increase these difficulties. The difficulty of visually observing evoked responses in an EEG is illustrated in Fig. XI-5.

Identical stimuli do not cause identical responses; thus, it is impossible to determine the exact waveform of a single response. However, the average waveform of the response to a repetitive identical stimulus may be determined by performing the crosscorrelation

$$\phi(\tau) = \int_0^T f(t)\, u_p(t-\tau)\, dt \qquad (1)$$

in which f(t) is the potential recorded from the brain, $u_p(t)$ is a train of impulse functions which is time-locked to the stimulus, τ is the relative delay of the impulses, and T is the period of observation (1, 2, 3, 4, 5). All of the operations necessary for performing the computation in Eq. 1 are identical with those performed in computing a regular crosscorrelation function except that here a continuous function is being multiplied by a series of unit impulses. Therefore, the analog correlator for electroencephalography described earlier (6) may be used for this computation by simply substituting a device capable of multiplying a continuous function by unit impulses for the regular multiplier. A block diagram of the modified correlator is shown in Fig. XI-6.

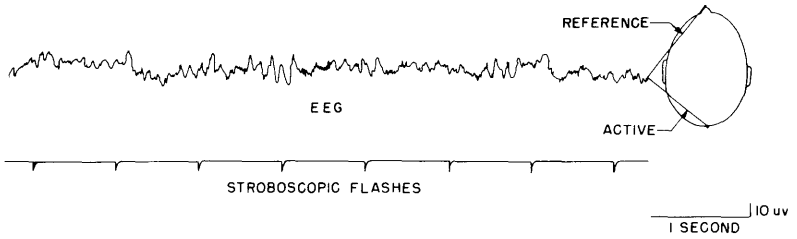

Fig. XI-5. Potentials recorded from skull of subject receiving stroboscopic flashes at times indicated by pips

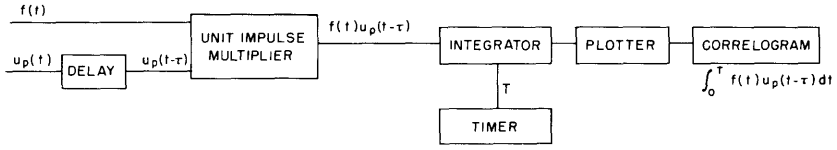

Fig. XI-6. Block diagram of system for computing the average response to repetitive stimuli

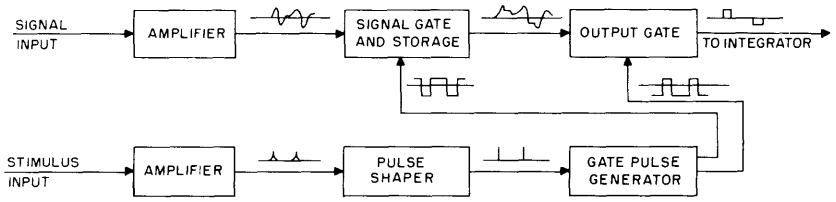

Fig. XI-7. Block diagram of device for multiplying bioelectric potentials by unit impulses

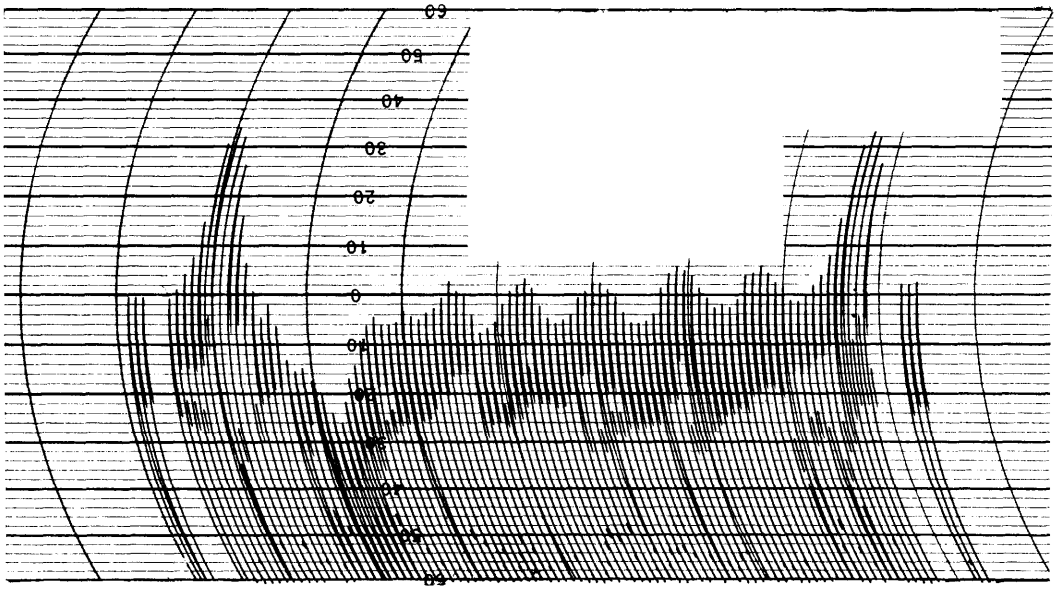

Fig. XI-8. Average of 100 responses to stroboscopic flashes presented every 850 msec. Each line represents a change in τ of 10 msec, where τ is measured from the onset of the flash. Recording electrodes were placed as indicated in Fig. XI-5.

If the unit impulse multiplier performs its function accurately, its output will be impulses with amplitudes equal to the instantaneous values of the brain potential at the times of occurrence of the impulses. Since the integrator is incapable of integrating pulses of zero width, the output of the multiplier has to be converted to rectangular pulses to provide adequate voltage-time area input to the integrator. A block diagram of a unit impulse multiplier with rectangular pulse output is shown in Fig. XI-7.

The important elements of this system are the gate pulse generator, the signal gate, the storage stage, and the output gate. The gate pulse generator converts the pulses which indicate the onset of the stimulus into two sets of rectangular gate pulses which are opposite in phase so that when the signal gate is closed the output gate is opened, and vice versa.

The signal gate is normally opened so that the storage section can follow the input. However, when the signal gate is closed, the value in storage is constrained at the instantaneous value of the signal at the time of closure. At this same instant, the output gate opens so that the constant value in storage is fed into the integrator until the end of the gating pulse. The width of the gating pulse is variable, but is kept short so that the system will be capable of handling random stimulation and still give equal weighting to each sample.

Figure XI-8 shows the average waveform of the activity evoked by a stroboscopic flash as recorded from the electrode positions indicated in Fig. XI-5. This average of 100 responses was computed from an 85-second sample of the activity from which Fig. XI-5 was taken. The 10-cps periodic activity resembles activity not ordinarily evoked by a flash but it is apparently time-locked to the periodic flashes.

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References

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