DIRECT CORTICAL RESPONSE IN THE CAT MOTOR CORTEX DURING SUMMATION

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Summation was studied by a procedure close to that used in producing a conditioned reflex. Subthreshold electrical stimulation, which gave rise to a dominant focus in the cat motor cortex, was applied after photic stimulation. Under these conditions, summation occurred both when the two stimuli were applied simultaneously and when the weaker stimulus preceded the stronger one by a very short interval (tens of milliseconds). Increased excitability was characteristic of the dominant focus. An excessive increase in excitability weakened the summation reflex. Electrographically, this type of conditioning was reflected in an increase in amplitude of the primary negative wave of the direct cortical response, recorded in the motor area at a distance of 2-3 mm from the stimulation point. It is concluded from analysis of this electrophysiological phenomenon and comparison of the results with data in the literature that different mechanisms are involved in the summation process during different sequences of stimulation ("photic + electrical" and "electrical + photic").

I. P. Pavlov and A. A. Ukhtomskii [3, 10] postulated that dominant processes may lie at the basis of conditioning. However, to compare the conditions required for formation of a conditioned reflex and for manifestation of a summation reflex during the dominant state, attention must be paid to differences not only in the relative strengths of the combined stimuli but also in the sequence of their application.

In order to elucidate the nature of the processes providing a basis for these phenomena, the same electrophysiological phenomenon - the direct cortical response (DCR) - was studied under different conditions of conditioning. In some experiments the sequence of the subthreshold stimuli was the same as in the dominant; in other experiments it was the same as in the conditioned reflex.

Electrical (dc) stimulation either preceded or was accompanied by flashes. Electrophysiological studies have shown that during conditioning manifested as contraction of a limb, a change is recorded in the DCR configuration, with increase in amplitude of the secondary negative wave [5].

The present investigation was a continuation of the cited work and its object was to find out whether summation can take place if the stimuli are applied in the opposite order. The electric current producing a dominant focus of excitation was applied after the action of light, i.e., the weaker stimulus preceded the stronger one.

EXPERIMENTAL METHOD

Forty-two acute experiments were carried out on cats lightly anesthetized with Nembutal (30 mg/kg, intraperitoneally). The experiment began 4-5 h after the operation (without any further administration of anesthetic). Places where the head muscles were pressed upon by the stereotaxic apparatus and the wound edges were injected with 1% novocaine solution. A burr-hole was drilled in the skull over the motor cortex, the dura removed and the center for the right fore limb was located. The stimulating electrode was placed on this center. A concentric electrode was used for bipolar stimulation. For unipolar stimulation, the reference electrode, a silver plate, was pressed against the oral palate. The electrode for recording potentials in the motor cortex was a silver wire with a thread wick on its end. The recording electrode was placed at a distance of 2-3 mm from the stimulating electrodes. Both stimulating and recording electrodes were coated with AgCl.

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Fig. 1. Summation in motor cortex in response to combination of subthreshold stimulation of cortical center for right fore limb and flashes (April 11, 1968).

A) Fragments of record: 1) stimulation of cortex with single dc potentials (6 V, 0.2 msec, 1 sec); 2) simultaneous combination of electrical and photic stimulation; 3) interval between stimuli 40; 4) 50, and 5) 100 msec. From top to bottom: time marker; marker of flasher; EEGs of motor and visual areas; limb movement. B) Dependence of amplitude of movement of right fore limb on interval between combined stimuli (40 responses). Abscissa, time (in msec); ordinate, amplitude of contraction in percent of amplitude of response to isolated electrical stimulation.

The brain was stimulated by square pulses of 0.2 msec duration, 0.2-1 Hz, at 1-2 min intervals. In experiments using currents of threshold intensity or over, single pulses were applied at 1-3 min intervals. An ESU-1 universal electrostimulator was used with radiofrequency attachment at the output.

The potential evoked by the photic stimulus was recorded by means of a silver ball from the lateral gyrus, in an area giving the best response to light. Electrical activity of the motor and visual areas was recorded by a monopolar electrode. The reference electrode was placed either in the bone over the frontal sinus or on the occipital protuberance (with unipolar stimulation to decrease the artefact).

Flashes (13.5-0.01 J; duration 30 msec) were generated by an FFS-1 photostimulator. Limb movements were recorded in two ways. The electromyogram was recorded with needle electrodes or mechanograms were obtained by means of a special device; the principle of its operation was that twitching of the muscle caused the movement of a magnet in an induction field [18].

An "Ediswan" electroencephalograph with output connected to a "Duascope" CRO was used to record the potentials. The beginning of the sweep was synchronized with application of the stimulus. A quantitative analysis was made of the DCR and EP latencies and amplitudes. An AI-400 analyzer was used for this purpose in two experiments. The significance of the change in the response was assumed by the Wilcoxon criterion.