RESPONSES OF SOMATIC CORTICAL NEURONS DURING THE CONDITIONED PLACING REFLEX IN CATS

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Unit activity was studied in areas 3 and 4 during the conditioned placing reflex in cats. Responses of somatic cortical neurons in this case were shown to develop comparatively late — 80-100 or, more often, 200-450 msec after the conditioned stimulus. In the motor cortex responses preceded movement by 50-550 msec, whereas in the somatosensory cortex they usually began simultaneously with or after the beginning of the movement. Judging from responses of somatic cortical neurons, the placing reflex is realized by the same neuronal mechanism as the corresponding voluntary movement. The differential stimulus and positive conditioned stimulus, after extinction of the conditioned placing reflex, evoked short-latency spike responses lasting 250-350 msec in the same neurons as took part in the reflex itself. In these types of internal inhibition, responses of the neurons were thus initially excitatory in character. Participation of the neurons in the conditioned placing reflex and its extinction, disinhibition, and differentiation, is the result of a change in the time course of excitatory processes and is evidently connected with differential changes in the efficiency of the various synaptic inputs of the neuron.

INTRODUCTION

Previous investigations showed that in the course of a conditioned defensive reflex to acoustic stimulation in animals spike responses of the somatic cortical neurons are nonhomogeneous and polyphasic in character. Nonhomogeneity of the responses and some degree of independence of their individual phases were clearly manifested during formation and extinction of the conditioned reflex (CR) and also during differentiation. Comparison of the phase of the spike responses with the beginning of conditioned-reflex movement showed that the phase of the initial spike response, developing against a background of increased excitability, essentially reflects the arrival of the afferent signal in the neocortex, whereas the phase of after-discharges, which correlates closely with the beginning of the conditioned-reflex movement, reflects changes in the discharge pattern of the neuron due to learning [5, 6].

To establish to what extent the polyphasic character of neuronal responses is a regular feature of conditioning it was important to study responses of somatic cortical neurons during
Fig. 1. Comparison of unitary responses evoked by unconditioned (a), conditioned (b), and differential (c) stimuli. 1, 2, 3) Responses of sensory, 4, 5, 6) of motor cortical neurons. Each horizontal line represents histograms of responses of same neuron. Abscissa, time, sec; ordinate, number of spikes. n) Number of realizations. Vertical lines indicate time of application of stimulus, short strokes below histograms denote intervals of latent periods of bicipital EMG responses.

It was postulated that a short weak triggering stimulus, such as is usually used in instrumental reflexes, would enable the initial response of the neuron to the conditioned stimulus to be reduced and the response of the neuron directly connected with performance of the CR to be obtained more distinctly. Responses of cortical neurons during an instrumental CR have been studied by many workers. According to their data [9, 10], responses in this case are monophasic, unidirectional in character. We have postulated that the true character of unitary responses during an instrumental reflex can be elucidated by comparing them with unitary responses arising during extinction and differentiation of this conditioned reflex.

The aim of the present investigation was thus to study the structure of responses of somatic cortical neurons during performance, extinction, and differentiation of a conditioned instrumental reflex.

METHOD

The conditioned placing reflex (CPR) was chosen as model of an instrumental reflex [1].

For training purposes and for the main experiment the cat was placed in a hammock; the animal's forelimbs hung down freely and the head was not fixed. During formation of the reflex, placing the limb after clicks and application of the tactile stimulus 1 sec later was reinforced by food. A conditioned motor response to sound appeared after 4-80 combinations. After conditioning (reproducibility 60-80%) the motor response was not accompanied by food reinforcement, and this led to its gradual extinction. When the reflex was established, differential and positive stimuli were presented alternately. Positive stimulation and subsequent placing were reinforced, whereas the differential stimulus was not reinforced whether a motor response appeared or not.

Touching the dorsal surface of the forelimb with a probe was the unconditioned stimulus and a single click with a loudness of about 60 dB and a total duration of 4 msec served as