UNIT ACTIVITY IN THE ASSOCIATION CORTEX OF CATS DURING FOOD-MOTIVATED BEHAVIOR

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UDC 612.833.39-08:612.825.1

Cortical unit activity was recorded in cats during long-term experiments and correlated with the animal's food-motivated behavior. The development of a food response in the cat was shown to correspond to a particular pattern of changes in unit activity in the association cortex. Changes in the level of spontaneous cortical unit activity were connected with manifestation of the animal's basic motivation.

It is now well known that any goal-directed activity of animals and man is based on a state of internal motivation. As an important component of afferent synthesis during the formation of behavior, motivating excitation arising primarily in specific subcortical structures selectively involves neurons at different brain levels to form the successive stages of goal-directed actions [1]. The food-getting behavioral response of animals, based on a state of hunger formed by the primary activity of the food centers of the hypothalamus, is constructed on this same principle [12, 14, 18]. Neurophysiological investigations have shown that motivating excitation connected with this state travels along many different pathways and spreads by different mechanisms to different regions of the cortex. Because of their ascending activating influences on the cortex the hypothalamic centers create a specific mosaic of excitation of cortical neurons, and this determines the food-getting behavior [5]. Analysis of unit activity in the anterior divisions [6] and sensory, orbital [4], and visual [9] areas of the cortex has shown that excitation from the food motivating center spreads in an ascending direction and mobilizes neurons in the cortex which previously had participated in the animal's food-motivated activity.

Meanwhile, investigation of unit activity in the association areas of the cortex during food-induced excitation is of great interest. These areas, belonging to the primary projection areas of the cortex, (visual, auditory, somatic) and responsible for interaction between the sensory systems of the brain, are essential for the formation of more complex behavioral acts than the simple identification of certain features of the stimuli [2, 3, 10]. However, it is only under long-term experimental conditions with correlation of the activity of a neuron with the animal's behavior that it becomes possible to understand the meaning of the whole variety of responses of the cortical neurons participating in the formation of the functional systems of the organism resulting ultimately in the obtaining of the final useful result of the action.

Activity of neurons in the parieto-occipital region of the cortex was studied in chronic experiments on cats during food-motivated behavior.

EXPERIMENTAL METHOD

Five cats were used. Before each experiment the cats received no food for 24 h.

Unit activity was recorded during free behavior of the animal by the method of Baust et al. [13] in the writers' modification [8]. A miniature micromanipulator with microelectrode weighing 8.5 g was fixed to the animal's head in a previously implanted metal base. The microelectrode was connected to a cathode

Department of Normal Physiology, I. M. Sechenov First Moscow Medical Institute. (Presented by Academician P. K. Anokhin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 75, No. 2, pp. 6-10, February, 1973. Original article submitted October 11, 1972.

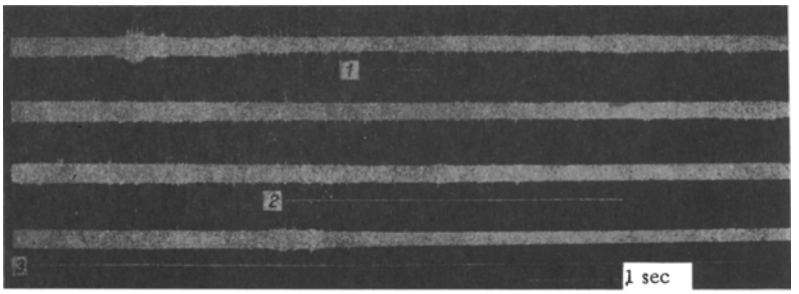

Fig. 1. Activity and responses of a neuron from the parieto-occipital region of the cortex: 1) signal "puss-puss;" 2) signal "puss-puss" and presentation of bowl of milk; 3) beginning of lapping.

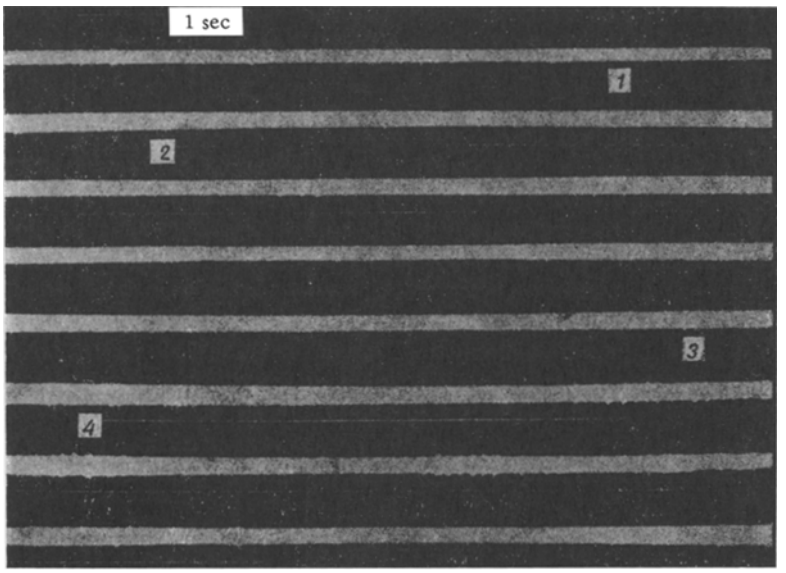

Fig. 2. Activity and responses of a neuron from the parieto-occipital region of the cortex: 1, 3) signal "puss-puss" and presentation of bowl of milk; 2, 4) beginning of lapping, end of marker corresponds to removal of bowl of milk.

follower by means of a long lead enabling the cat to move about freely in the screened cage. Unit activity was recorded by ordinary biopotential amplifiers.

EXPERIMENTAL RESULTS

Activity and responses of 52 cortical units in the parieto-occipital region (suprasylvian gyrus) were recorded. The spontaneous firing rate of the neurons studied varied from 1 to 30/sec depending on the animal's behavior at the time of recording. In the absence of external stimulation and with the cat in a position of rest the spontaneous firing rate of the test neuron became stabilized at a certain level. In some cases when the cat began to doze, an increase in the firing rate of the recorded neuron could be observed. Irrelevant external stimuli (light, sound, touch) evoked a primary and orienting reflex of the animal, manifested as a change in the position of the head, ears and eyes relative to the stimulus. During this time a transient change in the unit activity studied could be seen. During repeated application of the same stimuli only responses of the neurons took place without any visible behavioral responses of the animal.

At the signal "puss-puss" a bowl of milk was given to the cat. In response to this signal the cat turned its head toward the experimenter, while most (61.5%) of the neurons tested inhibited their firing for a short period of time (on the average for 1-2 sec; Fig. 1). Some neurons (30.8%) increased their activity at this time, and only a very few neurons (7.7%) remained areactive. At the sight of the bowl of milk the cat gave a motor response toward it and began to lap the milk. During the development of this type of food behavior

the activity of the tested units changed considerably, but only actually during the lapping. Most neurons (54%) showed sharply reduced activity a short time after the beginning of lapping, and sometimes the activity ceased altogether (Fig. 1); 33.8% of the neurons tested at this time showed increased activity, while 12.2% showed no change. In some cases the decrease in unit activity during lapping was followed by recovery or even by increased activity after feeding (Fig. 2). If the bowl of milk was removed while the cat was lapping, the unit activity changed sharply: in 43% of cases it increased and in 28.5% it decreased. Under these circumstances the cat showed no motor response. As a rule the direction of these changes was opposite to the unit responses during lapping.

Analysis of these results shows that the development of the food response in the cat corresponded to a dynamic pattern of changes in unit activity in the association cortex. If the development of food behavior of the cat is examined from the standpoint of the general structural pattern of any behavioral act [1], it is easy to distinguish the individual stages of formation of behavior and to compare them with the dynamics of activity and the responses of the cortical units tested. The triggering or conditioning stimulus, by which the animal's behavioral response begins to develop, is preceded by the perception of a large number of stimuli informing the animal about the situation (circumstantial afferentation). This continuous flow of stimuli creates a certain pattern of distribution of excitation in the CNS, reflected in the spontaneous unit activity. The system of excitation created in the CNS has a biological "tint" because of the motivation of hunger existing at that moment. The triggering stimulus, with the participation of the central mechanisms of memory, reveals this system of excitation and initiates the development of the behavioral act. In the present experiments this triggering stimulus was the signal "puss-puss." The animal's behavioral responses and the transient unit responses to this particular action evidently reflected to some degree the orienting behavior in response to that stimulus. Recruiting of neurons of the association cortex into orienting reflexes can take place through the wide convergence of excitation of different sensory modalities and also excitation from various subcortical structures and other regions of the cortex on them [11, 15-17, 19]. It is these mechanisms of the association cortex which permit the integration of excitation of different sensory systems to take place in the formation of complex behavioral acts.

Previous investigations by the writers [7] show that spontaneous activity of cortical neurons may reflect the biological state of the animal connected with existing motivations. The results of the present experiment show that a change in spontaneous unit activity is observed only after the animal has begun to lap the milk, i.e., after weakening of the basic motivation of hunger. If, however, the animal is interrupted in its act of satiation by removal of the bowl of milk, in both cases the spontaneous unit activity is increased, in the writers' opinion because of a change in the level of motivating excitation.

Comparison of unit responses in the association cortex during the development of orienting and food-motivated behavior shows that the number of neurons investigated which showed a uniform type of response in both cases is almost identical. This is evidently connected with the fact that, on the one hand, the signal "puss-puss" is frequently a signal for food-motivated behavior in the cat. On the other hand, by contrast with neurons of the cortical projection areas, neurons of the association area more often give prolonged tonic responses, expressed as a change in the overall level of spontaneous activity and connected with completion of the behavioral act, leading to a sharp decrease in the intensity of the initial motivating excitation.

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