RECIPROCAL EFFECTS OF THE DORSAL HIPPOCAMPUS AND MESENCEPHALIC RETICULAR FORMATION ON THE RESPONSE TO FOOD

V. G. Zilov and S. K. Rogacheva

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The influence of the dorsal hippocampus and mesencephalic reticular formation on the response to food evoked by hypothalamic stimulation was studied in chronic experiments on rabbits. Stimulation of the dorsal hippocampus was found to increase the threshold of the food response whereas stimulation of the mesencephalic reticular formation, on the other hand, lowered it. Recording the bioelectrical activity in various parts of the cortex and subcortex showed that inhibitory influences of the dorsal hippocampus on the evoked food response are produced entirely at the subcortical level.

According to Anokhin's theory of the functional system [1] biological motivations play an important role at the first stage of behavior formation – the stage of afferent synthesis. Motivation-induced excitation of the brain arising initially in the hypothalamus and spreading to the subcortex and cortex largely determines the subsequent behavior of the animals. Analysis of the neurophysiological mechanisms of behavioral responses, the basis of which is raising of the biological motivational level, provides convincing evidence of the role of the limbic structures and parts of the mesencephalon in their formation [3, 8, 17].

Despite the abundant evidence of participation of the limbic structures, especially the dorsal hippocampus, in responses to food, contradictory information has been obtained regarding the character of hippocampal influences. Besides inhibitory influences of the dorsal hippocampus on food responses [5, 9, 10] there is also convincing evidence of hippocampal influences of a facilitatory character [3, 4].

The object of this investigation was to study the effects of the dorsal hippocampus on a food response evoked by stimulation of the lateral hypothalamus and to compare them with influences arising from the mesencephalic reticular formation.

EXPERIMENTAL METHOD

Eighteen unimmobilized, unanesthetized rabbits weighing 2.5-3 kg were used. The animals taking part in the experiments had previously been fed and electrical stimulation of the "hunger center" evoked a distinct food response. Thin nichrome electrodes were inserted into the structures of the dorsal hippocampus and mesencephalic reticular formation as well as into the region of the lateral hypothalamus. To study the effects of the dorsal hippocampus and mesencephalic reticular formation on the threshold of the evoked food response electrical pulses (5 V, 50/sec, 1 msec) were applied to the above mentioned structures. Using needle electrodes the EEG was recorded from various parts of the cortex. Electrical activity of subcortical brain structures was recorded with implanted electrodes. The brain activity was recorded with a 15-channel Alvar electronic ink-writing electroencephalograph. The location of the subcortical electrodes was verified histologically.

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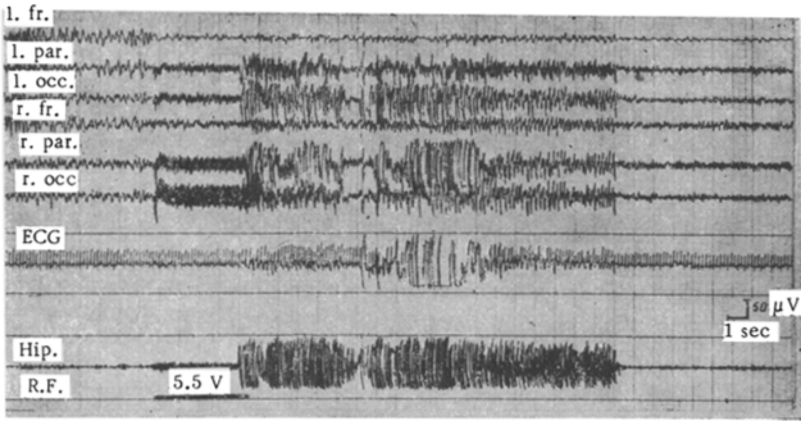

Fig. 1. Production of food response by isolated stimulation of mesencephalic reticular formation (5.5 V, 50/sec, 1 msec). From top to bottom: Left frontal, left parietal, left occipital, right frontal, right parietal, and right occipital regions of cortex, EEG, dorsal hippocampus, marker of stimulation of reticular formation. Calibration, (bottom right) 50 μV, 1 sec.

EXPERIMENTAL RESULTS AND DISCUSSION

The food response of unanesthetized unimmobilized rabbits evoked by stimulation of the lateral hypothalamus was accompanied by changes in electrical activity in various parts of the brain. In the dorsal hippocampus and mesencephalic reticular formation a regular rhythm developed, while in the cortical leads desynchronization was observed. The changes in cortical electrical activity varied from one animal to another. Frequently threshold stimulation of the "hunger center" sufficient to evoke a food response could be accompanied by desynchronization in the frontal areas of the cortex whereas a regular rhythm was observed in the other parts of the cortex.

Stimulation of the dorsal hippocampus was accompanied by an increase in the threshold of the evoked food response. The inhibitory effect of the hippocampus was particularly marked if test stimulation of the lateral hypothalamus was applied after stimulation of the hippocampus. Stimulation of the mesencephalic reticular formation, on the other hand, lowered the threshold of the evoked food response. In some experiments isolated stimulation of the mesencephalic reticular formation evoked a distinct food response of the animal with characteristic changes in subcortical and cortical electrical activity (Fig. 1).

Different types of influence of the dorsal hippocampus and mesencephalic reticular formation on the food response will be accompanied by different patterns of change in electrical activity of the brain structures. Stimulation of the mesencephalic reticular formation was followed by activation of the cortical EEG and the appearance of regular activity in the hippocampus. Stimulation of the dorsal hippocampus, raising the threshold of the evoked food response, on the other hand, did not give rise to changes in cortical electrical activity (Fig. 2).

The reciprocal character of effects of the dorsal hippocampus and mesencephalic reticular formation on the evoked food response and the differences observed in the pattern of cortical electrical activity under these circumstances contrasted sharply with the uniform changes in activity in these structures during threshold stimulation of the "hunger center." The appearance of a regular rhythm in the dorsal hippocampus and mesencephalic reticular formation during development of the food response naturally suggested that the structures examined were in an identical functional state, and also that they evidently had similar effects on the evoked food response if stimulated separately. However, the facts proved otherwise. Whereas the facilitatory character of the effects of the mesencephalic reticular formation on the food responses could easily be explained by the influence of activating structures of the brain stem of a "general nonspecific" character with respect to behavior [17], it is more difficult to explain the hippocampal influences. Inhibitory effects on the food response in animals have frequently been described [5, 9, 10]. Moreover there is evidence to show that stimulation of the hippocampus does not disturb sleep [14], and can evoke an "arrest reaction" in animals [13, 15] and inhibit behavioral responses of different biological types [5, 7]. These observations have led some workers to regard the hippocampus as belonging to the nonspecific inhibitory

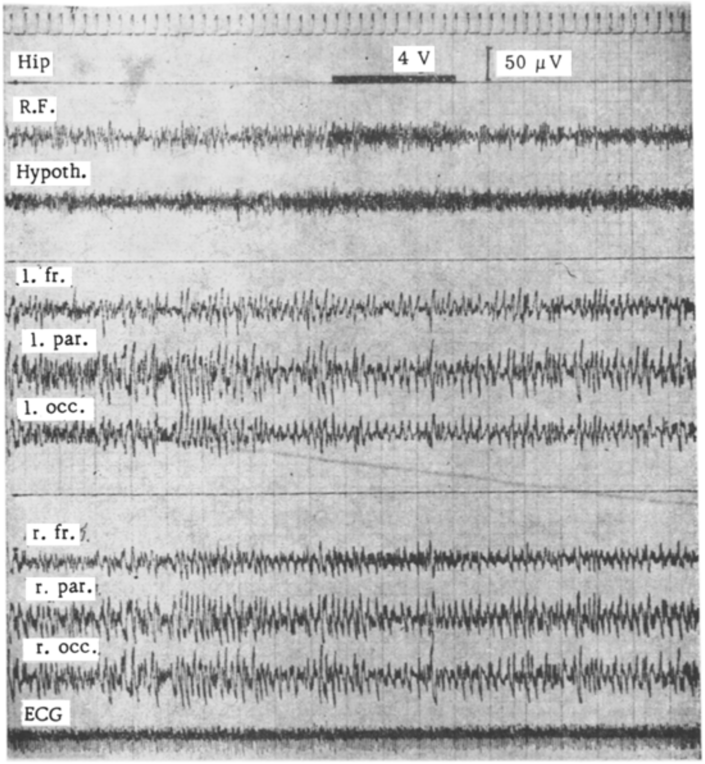

Fig. 2. Activity recorded in different parts of the brain in response to stimulation of the dorsal hippocampus (4 V, 50/sec, 1 msec). From top to bottom: time marker, marker of stimulation of dorsal hippocampus, mesencephalic reticular formation, lateral hypothalamus, left frontal, left parietal, left occipital, right frontal, right parietal and right occipital regions of cortex, EEG.

system of the brain [11, 12]. Meanwhile the numerous "rebound" phenomena after stimulation of the dorsal hippocampus [5, 14, 16] and, finally, its facilitatory effects on various behavioral responses including those to food [3, 4], suggest that relationships between the hippocampus and mesencephalic reticular structures are not only reciprocal in character [2, 6]. Recording the electrical activity of different parts of the brain in the present experiments during the food response to stimulation of the hippocampus and mesencephalic reticular formation provides the basis for a definite conclusion: facilitatory influences of the reticular formation of the food response are formed at both cortical and subcortical levels, while inhibitory influences of the dorsal hippocampus are entirely subcortical in their mechanism.

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