ROLE OF SENSORY STIMULI IN THE FORMATION OF CORTICAL EFFECTS ON HYPOTHALAMIC STRUCTURES

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Unit discharges were recorded in the ventromedial and posterior hypothalamic nuclei of immobilized cats during electrical stimulation of the ipsilateral and contralateral nerves of the brachial plexus, somatosensory areas I and II (SI and SII) of the visual cortex, and the mesencephalic reticular formation. Reversible cold block of areas SI and SII did not change the effects of nerve stimulation. Stimulation of the posteroventral thalamic nucleus did not change spontaneous activity during stimulation of SII. Cortical influences on hypothalamic structures arising during stimulation of nerves and the posteroventral thalamic nucleus are thus mild in degree.

KEY WORDS: hypothalamic nuclei; cerebral cortex; corticofugal influences.

In the modern view [1, 14, 19, 21] cortico-hypothalamic interrelations form the neurophysiological basis of various types of motivated behavior as well as of unconditioned responses arising by a conditioned-reflex mechanism in the sphere of autonomic regulation. The reticular formation and also a group of structures collectively known as the limbic system [6, 11] participate directly in cortico-hypothalamic interaction. However, the cerebral cortex and hypothalamus, together with the reticular formation, are apparently the initial components of processes manifested externally as various behavioral and regulatory acts. Substantial progress has now been made in the study of the neuronal mechanisms of ascending hypothalamic influences on the cortex [1, 4, 10, 11]. However, despite neuroanatomical [2, 8, 19, 21, 24] and neurophysiological [3, 15-17, 24] data on the existence of direct and polysynaptic connections between the cerebral cortex and hypothalamus, the functional significance and the role of these connections have still received little study.

The object of the present investigation was to determine whether afferent stimuli traveling to the projection areas of the cortex can participate in the formation of cortical influences on single neurons of the ventromedial and posterolateral hypothalamic nuclei and to determine the character of those effects.

EXPERIMENTAL METHOD

Cats were immobilized with listhenon. Single-unit responses were recorded in the ventromedial (VMN) and posterior (PHN) hypothalamic nuclei to stimulation of nerves of the right and left brachial plexuses, the posteroventral thalamic nucleus (PVN), somatosensory cortical areas I and II (SI and SII), and the mesencephalic reticular formation (RF). Reversible cold blocking of areas SI and SII was produced by spraying the cortical surface with ethyl chloride.

EXPERIMENTAL RESULTS

Responses of 72 single units were recorded in the region of VMN and PHN, 70% of them characterized by spontaneous activity with a discharge frequency of 1-2 to 10-12/sec. The rest of the neurons responded to stimulation by one or more discharges with a latent period of not less than 12-14 msec and not more than

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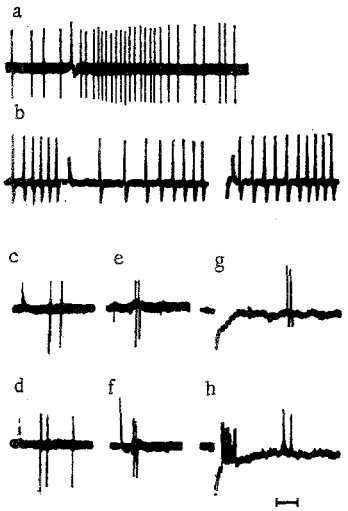

Fig. 1. Unit responses of right hypothalamic VMN to electrical stimulation: a, b, f) stimulation of area SII of right hemisphere; c, e) nerves of left, and d) nerves of right brachial plexuses; g) of visual cortex; h) mesencephalic reticular formation. Time marker 25 msec.

30-35 msec. Some (40%) of the spontaneously active neurons responded to stimulation of nerves of the brachial plexus and of area SII by an increase or decrease in discharge frequency (Fig. 1a, b). However, responses of these neurons to nerve stimulation remained unchanged during cold blocking of area SII. They likewise did not respond to stimulation of thalamic PVN with an intensity sufficient to induce evoked potentials in the ipsilateral projection areas SI and SII.

Some neurons responded only to stimulation of nerves (Fig. 1c, d), others responded both to electrical stimulation of the nerve (Fig. 1e) and to stimulation of area SII (Fig. 1f).

Evoked responses of six hypothalamic neurons were also recorded during stimulation of the visual cortex (Fig. 1g). These neurons did not show convergent properties and their responses were characterized by a comparatively long latent period (30-40 msec). Stimulation of mesencephalic RF had a mainly inhibitory effect on the spontaneously active neurons, and only a few cells showed an increase of the spontaneous discharge frequency (Fig. 1h). Stimulation of mesencephalic RF under these conditions did not lead to the appearance of any effects of stimulation of the thalamic PVN.

The latent period of responses of the hypothalamic neurons evoked by stimulation of area SII (14-18 msec) indicates that these responses have polysynaptic pathways. Possibly cortical influences on hypothalamic neurons observed in the present experiments during direct stimulation of area SII are mediated through the posterolateral nuclei. The amygdalar nuclei in which, as some workers [13, 18] have found, evoked potentials are clearly recorded during stimulation of area SII and also of thalamic PVN, cannot be ruled out as participants in the mechanism of the cortico-hypothalamic effects. It has been conclusively established [9, 20, 22, 23] that the amygdalar nuclei have well-developed two-way anatomical connections with the ventromedial hypothalamic nuclei. The problem of the actual intermediate structures transmitting cortical effects to the hypothalamic structures, especially from area SII, is of considerable interest and its study is being planned in the near future.

From the point of view of the object of the present investigation the most important results are the negative results of generation of cortico-hypothalamic influences in response to stimulation of the peripheral nerves and PVN. However, during stimulation of this kind cortical effects on hypothalamic structures must nevertheless be considered to arise, but they are evidently below the threshold required to excite or to significantly modify spike activity of the hypothalamic neurons. This explanation seems very likely if the investigations of Rusinov [7] are recalled; these showed that previously indifferent acoustic or photic stimuli, after comparatively weak electrical polarization of hypothalamic structures, are capable of inducing changes in respiration and cardiac activity that were not observed before polarization.

The possibility of inducing cortical effects on hypothalamic structures by direct stimulation of area SII and the inability of corticopetal afferent stimuli (during stimulation of thalamic PVN) to cause the generation of these influences are also evidence of the possible weakness of selective relaying processes in cortical neurons. Besides the factors lowering the thresholds of excitability of hypothalamic neurons, the role of ascending hypothalamo-cortical influences, which evidently facilitate or potentiate relaying processes, must also be taken into account. The importance of this factor, as the work of Hori [5, 12] has shown, is particularly clearly seen in conditioned-reflex changes in unit activity during intracerebral stimulation.

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