CHARACTERISTICS OF RETICULAR AND NOCICEPTIVE INFLUENCES ON THE POLYSYNAPTIC EXTENSOR REFLEX

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Soon after the areas of the bulbar reticular formation possessing facilitatory and inhibitory influences had been described, experiments were carried out in which the higher formations of the mesencephalon and diencephalon were found to possess analogous functions [1, 5, 6, 8, 10, 12, 15, 16].

Since the convergence which exists permits interaction between competing excitations at different levels, it was necessary to verify whether the segmental reflexes could be influenced both by descending excitation and by excitation ascending from the periphery, taking account of the data already obtained on this question [3, 7, 19], indicating the influence of nociceptive stimulation on peripheral motor activity.

The object of the present investigation was to study the relationships between the descending inhibitory influence of the mesencephalic reticular formation and segmental thermal nociceptive stimulation of the hind limb using an extensor reflex (of the knee) as indicator.

EXPERIMENTAL METHOD

Experiments were carried out on 20 adult cats. Under Nembutal anesthesia (35 mg/kg body weight, intraperitoneally) the anterior crural nerve was dissected, the branch leading to the rectus femoris muscle was divided, and its central end was placed on electrodes. By means of a capacitance detector, the movement of the limb was recorded on a "Racia" ink-writing polygraph. The nociceptive stimulus was water at a temperature of between 55 and 65°. The hair was cut from the contralateral hind limb relative to the recording, and the limb was then immersed in a vessel of hot water. The subcortical structures were stimulated by means of bipolar stainless steel electrodes, 1.2 mm apart, introduced stereotaxically into the structures of the mesencephalon.

To obtain spinal animals, the spinal cord was divided at the level L_1-L_2.

The electroencephalogram (EEG), electrocorticogram (ECoG), the mechanogram, and respiration were recorded.

EXPERIMENTAL RESULTS

Stimulation of the mesencephalic reticular formation with rectangular pulses of electric current (3-8 V) caused a marked decrease in the amplitude of the knee jerk, which disappeared completely in some experiments. At the same time, a decrease was observed in the amplitude of the respiratory movements although their frequency was unchanged; sometimes respiration ceased. With weak stimulation, when the descending inhibitory effect of the mesencephalic reticular formation was not pronounced, changes were observed in the respiratory component of the reaction.

So far as the ascending influences of the reticular formation on the cerebral cortex are concerned, with anesthesia of average depth, as a rule they took the form of a desynchronization reaction (low-amplitude, high-frequency activity).

A higher temperature modified the motor activity causing inhibition of the knee jerk which continued for some time after nociceptive stimulation had ceased. In some cases the changes in motor activity occurred in phases: an initial facilitation was followed by inhibition of the knee jerk.

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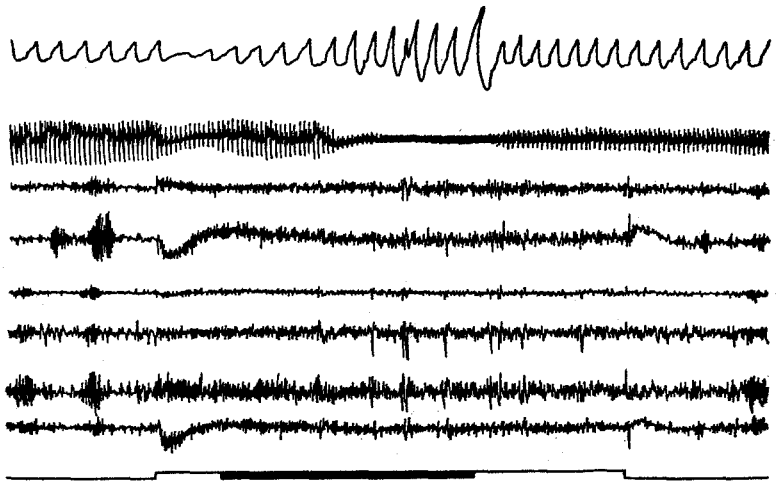

Fig. 1. Changes associated with the combined action of stimulation of the mesencephalic reticular formation and nociceptive stimulation. From top to bottom: respiration; mechanogram; ECoG of left frontal and temporal areas of the cortex; EEG of right frontal, temporal, parietal, and occipital areas of the cortex; marker of stimulation of the mesencephalic reticular formation and of the action of the nociceptive stimulus (black line). Stimulation of the reticular formation by a current of 5 V, with frequency 300 cps and pulse duration 0.1 msec; nociceptive stimulation – water at a temperature of 60°.

Besides its peripheral action, nociceptive stimulation also affected the higher levels of the central nervous system, modifying the cortical electrical activity, leading to disappearance of the characteristic spindles of Nembutal anesthesia and to the appearance of high-frequency, low-amplitude activity, continuing for some time after stimulation had been discontinued. The changes in respiration consisted of a gradual increase in the amplitude of the respiratory movements and, at the same time, an increase in their frequency.

The interaction between the inhibitory effect of the mesencephalic reticular formation and nociceptive stimulation is shown in Fig. 1. Deepening of the inhibition of the knee jerk, changes in the cortical electrical activity, and changes in the animal's respiration, which changes its "reticular" character for "nociceptive," may be observed.

Intramuscular injection of chlorpromazine (5 mg/kg body weight) modified the effects of the mesencephalic reticular formation and of nociceptive stimulation in different ways. In this dose, chlorpromazine blocked the action of nociceptive stimulation, but to abolish the inhibitory effect produced by stimulation of the mesencephalic reticular formation, a larger dose of chlorpromazine had to be given.

Nociceptive stimulation caused inhibition of the polysynaptic extensor reflex both in animals with low transection of the spinal cord and in intact animals (Fig. 2b). This reaction appeared approximately 15 min after transection of the spinal cord. In two of the seven animals, presumably on account of the considerable trauma, in response to nociceptive stimulation the motor reaction was completely absent. In the other animals inhibition of the extensor reflex was complete or partial. Intramuscular injection of chlorpromazine (5-7 mg/kg) abolished the inhibitory action caused by nociceptive stimulation in its various manifestations (Fig. 2c).

When examining the effects of stimulation of the mesencephalic reticular formation and of nociceptive stimulation, like other investigators [2, 4], the author observed that the difference in their effects extended to all parts of the nervous system including the cortex. So far as their effects on peripheral motor activity are concerned, in the present experiments inhibition of the polysynaptic extensor reflex was found. The additional application of nociceptive stimulation, despite the width of its effects, did not change the inhibitory action of the parts of the mesencepahlic reticular formation on the segmental reflexes.

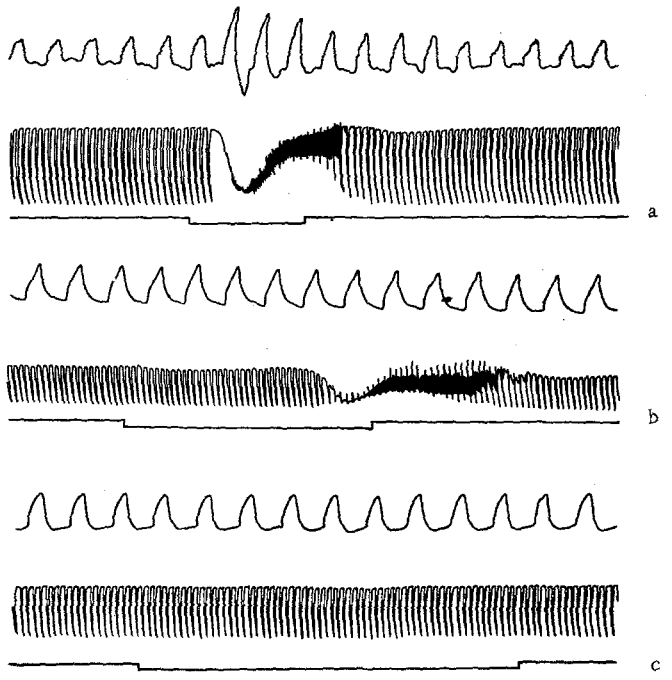

Fig. 2. Effect of chlorpromazine on the inhibitory action of nociceptive stimulation in spinal animals. a) Action of nociceptive stimulation before division of the spinal cord (temperature 60°); b) action of nociceptive stimulation after division of the spinal cord (temperature 60°). Absence of changes in respiration with maintenance of inhibition of the extensor reflex; c) absence of effect of nociceptive stimulation on the extensor reflex after intramuscular injection of chlorpromazine (7 mg/kg body weight). a-c (from top to bottom): respiration, mechanogram, stimulation marker.

Inhibition of the polysynaptic extensor reflex during the action of nociceptive stimulation was more sensitive to chlorpromazine than the inhibition produced by descending impulses from the inhibitory portions of the mesencephalic reticular formation. The results of experiments on animals with low transection of the spinal cord show that chlorpromazine can produce its effect also at the spinal level. This possibility was indicated by earlier investigations [14, 17]. In the most recent work [9, 11] it has been suggested that the most probable point of application of chlorpromazine is the internuncial neurons sensitive to the action of noradrenalin. The mechanism of action of nociceptive stimulation is evidently adrenergic in nature not only at the supraspinal, but also at the spinal level. The lower sensitivity of the descending inhibitory influences of the mesencephalic reticular formation to chlorpromazine may be explained by the more varied pathways which they follow [13, 18].

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