# AFFERENT INFLUENCES FROM THE URINARY BLADDER ON THE HYPOTHALAMUS

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Considerable experimental evidence exists of the efferent influences arising from the hypothalamus. Many experiments involving stimulation of various parts of the hypothalamus have shown that stimulation of this portion of the central nervous system causes, besides autonomic reactions, definite changes in the motor activity of the urinary bladder [9, 13, 17-20].

The afferent function of the hypothalamus has not yet received adequate study; most investigations have been concerned with its somatic influences [4, 11] and its role in the formation of the sensations of hunger, satiety and thirst [2, 3, 5, 6, 8]. Changes in the electrical activity of the hypothalamus during spontaneous and evoked fluctuations of the intravesical pressure have been recorded in only one study [16], undertaken on cats in acute experimental conditions.

The object of the present investigation, a continuation of a series of researches aimed at studying visceral projections in various parts of the central nervous system, was to determine the presence of afferent connections between the hypo- and subthalamic structures and the receptor apparatus of the urinary bladder.

## EXPERIMENTAL

Acute experiments were conducted on 28 adult cats anesthetized by intravenous injection of thiopental sodium (80 mg/kg). Potentials were recorded from the cerebral cortex by means of silver button electrodes, and from the hypothalamus by means of steel needles, insulated with lacquer, with a point 40-60 $\mu$ in diameter, inserted by the aid of a Horsley—Clark apparatus. Monopolar leads were used. The indifferent electrode consisted of a button fixed over the frontal sinuses. Biopotentials were recorded on an eight-channel, ink-writing electroencephalograph. The receptors of the urinary bladder were stimulated by injecting 40-80 ml of warm physiological saline through a cannula inserted into the urethra. In some experiments the position of the hypothalamic electrodes was verified histologically. The brain was perfused with a 10% solution of neutral formalin and serial sections were cut on a freezing microtome. These sections were stained by Nissl's method. A photograph of a frontal section through the brain is given in Fig. 1. The recording electrode was located in the dorso-lateral hypothalamus.

## RESULTS

The biopotentials of the lateral, posterior, dorsal, anterior and ventro-medial nuclei of the hypothalamus, of the mammillary bodies and of the zona inserta of the subthalamic region were recorded. The electrical activity of these formations consisted of irregular waves varying in amplitude from 30 to 300 $\mu$V. In response to stimulation of the bladder receptors, a change in the pattern of the electrical activity was observed in all the nuclei. The clearest results were obtained during recording of the potentials in the lateral hypothalamus. Of the 172 stimuli applied, 116 produced responses in the lateral hypothalamic nucleus expressed either as an increase in the frequency and amplitude of the biopotentials, or as a marked weakening of the bioelectrical activity. The latter was usually observed

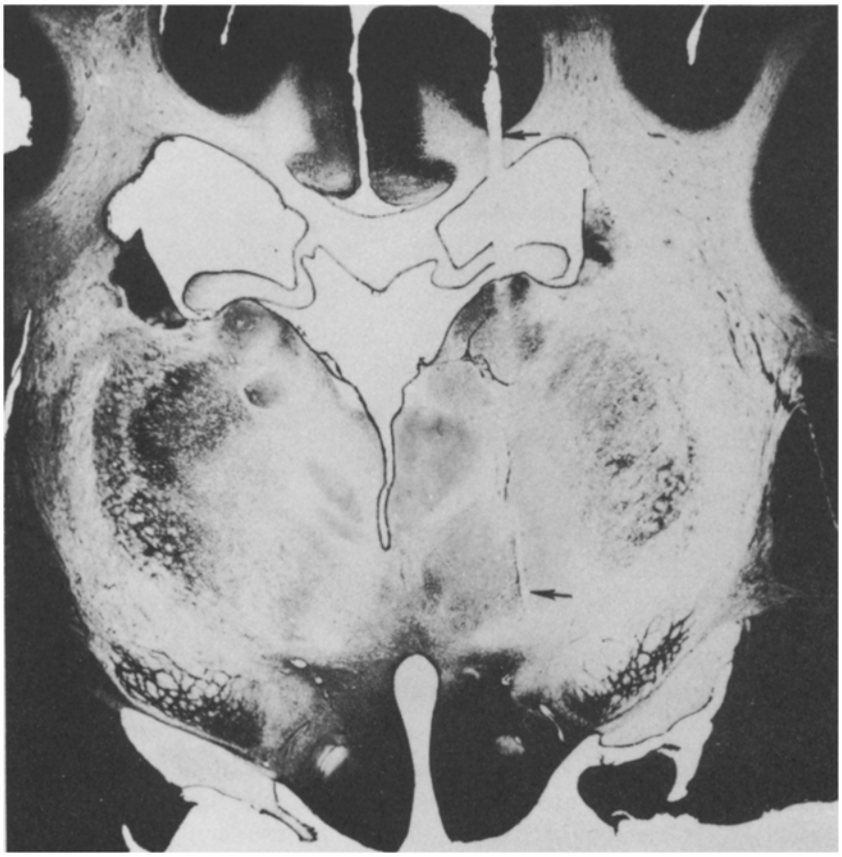

Fig. 1. Photograph of a frontal section through a cat's brain. The arrows indicate the position of the recording electrode in the dorso-lateral hypothalamus. Nissl's method. Magnification 10X.

when the physiological saline was evacuated from the bladder. If the bladder was left filled, the amplitude and frequency of the potentials in most cases remained higher than initially. The increase in the activity in the cerebral cortex and the lateral hypothalamus during filling of the bladder and the weakening of the activity during emptying may be seen in Fig. 2.

The lateral hypothalamus did not react uniformly everywhere to stimulation of the bladder receptors. The most responsive zone was the part of the nucleus lying in the 12th frontal plane of coordinates in the stereotaxic atlas of Jasper and Ajmone-Marsan, where 49 of 62 stimuli were effective (23 were recorded during filling and 26 during emptying of the bladder). In the same lateral nucleus, but slightly more orally (plane 9), fewer responses (68 of 110) were observed and these were mainly reactions to emptying of the bladder (38 effective stimuli, 17 ineffective), whereas the responses to filling the bladder were distributed almost evenly (30 effective, 25 ineffective).

Similar results were obtained when the potentials were recorded from the posterior hypothalamus, where more clearly defined changes in electrical activity also developed in response to emptying of the bladder.

In the dorsal hypothalamus,the increase and decrease in the strength of the biopotentials during stimulation of the bladder receptors were less marked than in the lateral nucleus. In the case of the anterior and ventro-medial nuclei and of the mammillary bodies, only 40-50% of the applied stimuli were effective, and these were mainly accompanied by a weakening of the current pattern of activity during emptying of the bladder.

The recordings of the biopotentials in the subthalamic region of the zona inserta showed that interoceptive stimuli produced changes in the original electrogram. A decrease in the volume of the bladder proved most effective in this case also.

Besides the biopotentials of the hypothalamic structures, the activity of the somatosensory cortex of Area 1 also was recorded. When the bladder was sufficiently filled, a marked increase in the frequency of the barbiturate

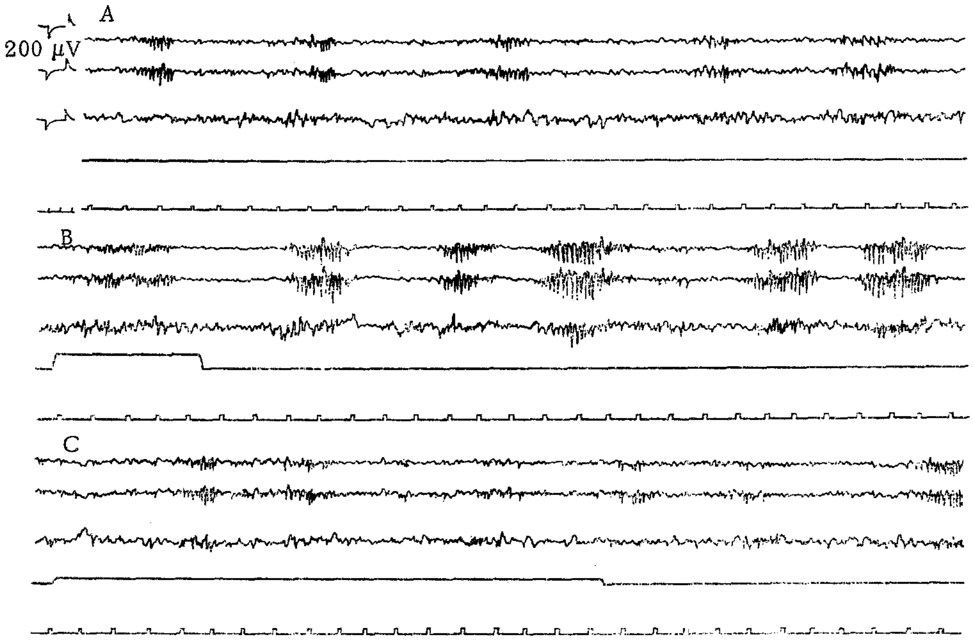


Fig. 2. Changes in the electrical activity of the cortex and lateral hypothalamus during filling and emptying of the bladder. A, B, C) continuous recordings. The top two tracings are electrocorticograms from the anterior sigmoid gyrus, the bottom is a hypothalamus. The first marker of stimulation denotes filling of the bladder, the second—emptying of the bladder.

volleys was observed in the zone of cortical representation of the viscera, accompanied in some cases by an increase in the frequency and amplitude of the waves composing them (Figs. 2B and 3B). After emptying of the bladder, the electrocorticogram gradually returned to its initial level (Figs. 2C and 3C). Since stimulation of the bladder did not always produce clear changes in the electrical activity of the hypothalamus, the changes in the electrocorticogram were constant, the latter was used as a special control to verify that the bladder receptors had in fact been stimulated.

The experimental results show that in response to stimulation of the bladder receptors changes in electrical activity developed in nearly all the investigated zones, and these were expressed as an increase or a decrease in the existing biopotentials. The degree of these changes varied with the location of the recording electrodes: the clearest results were obtained with recordings from the lateral hypothalamus, then from the dorsal, the posterior and, finally, the anterior and medial hypothalamus. On account of this generalization of the response reactions to interoceptive stimulation, it was impossible to distinguish in the hypothalamus a localized zone of afferent representation of the bladder receptor apparatus.

Similar results indicating the widespread involvement of the hypothalamic structures in the response reactions to fluctuations of intravesical pressure have been described by Porter and Bors [16], and also by other workers [4, 11] who recorded the primary responses in the hypothalamus during stimulation of the radial and sciatic nerves.

The hypothalamus is known to possess numerous anatomical connections with various portions of the limbic system [10, 12], and in the opinion of many writers [1, 14, 15] it is a component of the "visceral brain." It is easy from this point of view to explain the changes in activity taking place in the hypothalamus during stimulation of the internal organs. However, on the basis of the findings described, it cannot be decided whether these changes are primary or whether they are mediated through other structures contained in the interoceptive analyzer, and exerting an influence on the hypothalamus—i.e., it is impossible to define the path followed by the afferent impulses from the viscera to the hypothalamus. Although Anand and Dua [7] also regard the hypothalamus as a primary receptor and effector center of autonomic impulse activity, this cannot be accepted for their hypothesis rests on inadequate experimental proof.

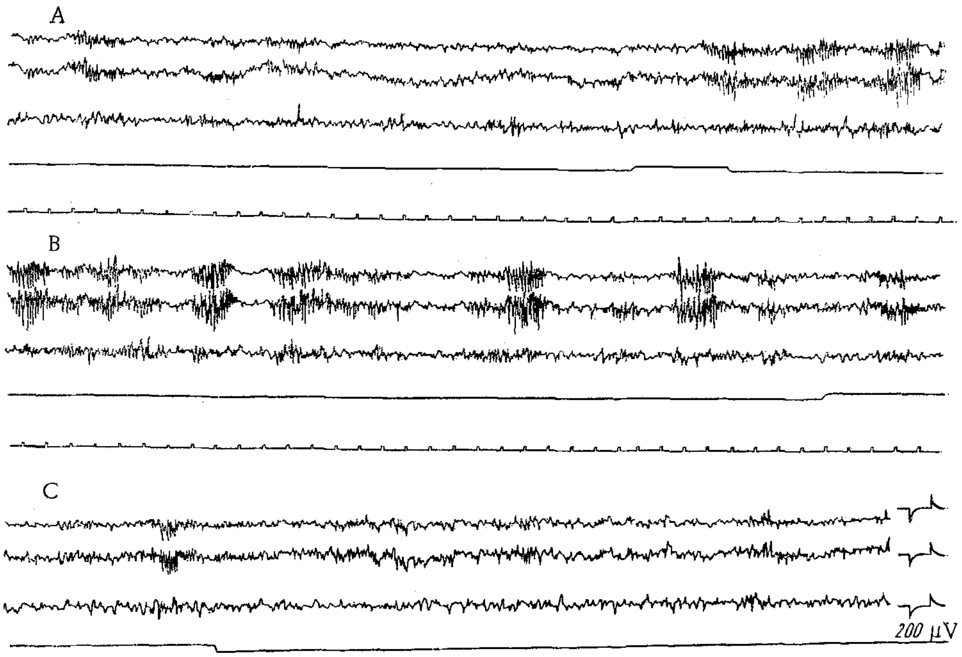

Fig. 3. Changes in the electrical activity in the cortex and dorsal hypothalamus during filling and emptying of the urinary bladder. Legend as in Fig. 1.

The cerebral cortex, as the highest regulatory center, undoubtedly also influences the hypothalamus. Evidence of this, in the authors' opinion, is given by the synchronization of the cortical and hypothalamic rhythms observed in some experiments during interoceptive stimulation. Usually the electrical activity of the hypothalamus of animals anesthetized with barbiturates took the form of irregular waves of different amplitudes, whereas in the cortex a well defined "volley" type of rhythm was recorded. During prolonged filling of the bladder, when the volleys in the cortex were much more frequent and the amplitude of their waves was increased, a synchronized "volley" activity developed in the hypothalamus. On the other hand, however, it cannot be denied that influences from the hypothalamus also reach the higher levels of the central nervous system. For example, K. V. Sudakov [3], who worked with fasting animals, discovered that the frontal region of the cortex can be activated from the food center in the hypothalamus.

Another possibility is that the changes in hypothalamic activity recorded in the present experiments reflect merely the functional state of its efferent structures during the performance of a certain working act. This is suggested by the more clearly defined reactions to emptying than to filling of the bladder.

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