ELECTROPHYSIOLOGICAL ANALYSIS OF ASCENDING ANTERIOR HYPOTHALAMIC INFLUENCES ON THE CORTEX OF UNANESTHETIZED RABBITS

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The effect of stimulation of the anterior hypothalamus on primary responses (PR) of the visual cortex was studied in unanesthetized rabbits with electrodes implanted in the brain. Weak stimuli (3-6 Hz, 0.4-1 V) applied to the hypothalamus cause facilitation of PR, while strong stimuli (60-80 Hz, 2-4 V) inhibit them. The facilitation reaction is longer in duration and more marked in degree than the inhibition reaction.

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Participation of the hypothalamus in determination of the physiological state of the cerebral cortex is not now disputed. However, the character of the influence of its individual parts on processes taking place in the cortex have not yet been adequately studied, and the data available on this question are contradictory. With respect to the anterior hypothalamus, both synchronizing [2, 9, 10] and desynchronizing [1, 8] influences on cortical electrical activity have been described. Analysis of these data shows that different methods were used for these investigations, and this may account for the different results obtained. One of the conditions determining the nature of the hypothalamic influence on the cortex is evidently the character of its stimulation.

To verify this hypothesis, the present investigation was therefore carried out. Its object was to study the relationship between influences of the anterior hypothalamus on cortical function and the intensity of hypothalamic stimulation.

EXPERIMENTAL METHOD

Experiments were carried out on 10 unanesthetized rabbits with electrodes implanted into the brain, their localization in the hypothalamus being verified histologically. In these experiments the effect of weak (3-6 Hz, 0.4-1 V) and strong (60-80 Hz, 2-5 V) electrical stimulation of the hypothalamus on electrical activity of the visual cortex was studied. Cortical electrical activity was investigated by the method of evoked potentials (EP) in response to photic stimulation, compared with changes in the integral ECoG, and the heart and respiration rates. EP were recorded by monopolar leads on a "Disa" universal indicator and a "Kaiser" ink-writing encephalograph, simultaneously with the ECoG, ECG, and respiration. Positive deflection of the primary responses (PR) was analyzed. The value of the positive deflection was determined from the arithmetic mean of 5 successive responses to single flashes at intervals of 5 sec. Significance of the results was determined statistically by the difference method [3]. The technique is described more fully elsewhere [5].

EXPERIMENTAL RESULTS

Recording of EPs in the visual cortex in response to a single photic stimulus, in unanesthetized rabbits adapted to the experimental conditions, revealed a definite configuration of the EPs in the focus of maximal activity. In most cases the EP was a complex multiphase wave with a latent period of 18-25 msec. According to results obtained by other workers [4, 6, 7], the initial biphasic deflection of this wave can be regarded as the primary response to photic stimulation. Repeated adaptation of the animals to the experimental conditions and photic stimulation created definite stabilization of the amplitude of the PR, so that

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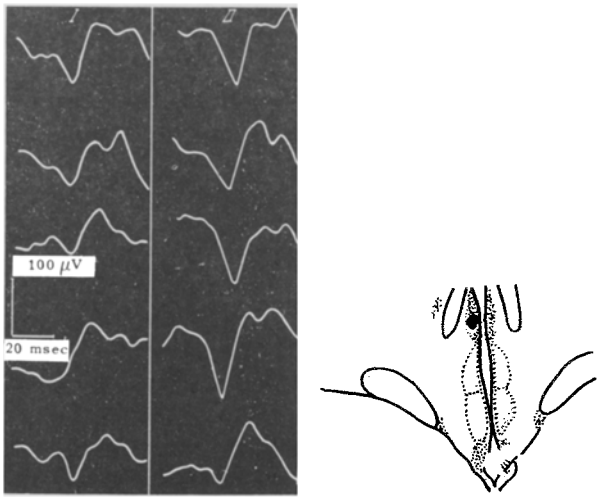

Fig. 1. Increase in amplitude of primary responses of visual cortex during weak (6 Hz, 0.6 V) stimulation of the paraventricular nucleus of the hypothalamus in an unanesthetized rabbit. Region of stimulation shown diagramatically at right. I) Before stimulation; II) during stimulation.

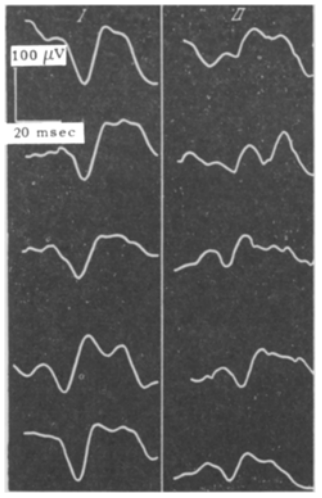

Fig. 2. Decrease in amplitude of primary responses of visual cortex during strong stimulation (80 Hz, 3 V) of the paraventricular nucleus of the hypothalamus. I) Before stimulation; II) during stimulation.

the arithmetic mean of 5 successive responses changed only very slightly in the course of an experiment without irrelevant stimulation.

Weak stimulation of the anterior parts of the hypothalamus (lateral preoptic region, medial preoptic region, lateral region of the hypothalamus, paraventricular nucleus) caused an increase in amplitude of the PR (Fig. 1); the reaction of PR facilitation took the form of a resultant increase of 64% in the positive deflection, on the average from 55±6.9 to 90±6.1 μV (M±m). Facilitation of the PR as described above was accompanied, as a rule, by an increase in amplitude of the background electrical activity, and the appearance of slow waves and spindle activity in the ECoG. Meanwhile, the heart and respiration rates were slowed. Only occasionally were no changes found in the ECoG at a time of considerable increase in amplitude of the PR. These changes in PRs and background electrical activity appeared in response to weak stimulation of the anterior hypothalamus actually during application of the stimulus, and they frequently were increased after its discontinuation (Fig. 3, I).

Strong stimulation of the hypothalamus through the same electrodes reduced the PR amplitude (Fig. 2) from 53±4.3 to 42±20 μV. The positive deflection of the responses was reduced on the average by 20%. The decrease in PR amplitude was accompanied by development of an activation reaction in the ECoG. No definite relationship could be found between the decrease in PR amplitude was accompanied by development of an activation reaction in the ECoG. No definite relationship could be found between the decrease in PR amplitude and change in the heart and respiration rates. It was noted that the response of decreased PR amplitude and decreased background electrical activity of the visual cortex during strong stimulation of the hypothalamus was observed mainly during application of the stimulus and disappeared quickly after its removal (Fig. 3, II).

The influence of the anterior hypothalamus on PRs of the visual cortex was exhibited bilaterally, but was more marked on the ipsilateral side.

Experiments in which the frequency and voltage of the stimuli were increased gradually showed that changes in cortical PRs develop sooner than visible changes in background electrical activity, and are manifested in response to stimulation of lower intensity than changes in the heart and respiration rates. This fact indicates the superiority of the EP method for the study of changes in cortical electrical activity under the influence of subcortical stimulation.

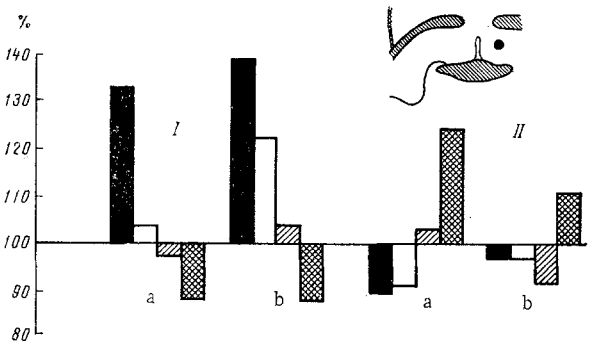

Fig. 3. Changes in positive deflection of primary responses of visual cortex, in background electrical activity, and heart and respiration rates during stimulation of medial preoptic region of hypothalamus (initial value of calculated indices taken as 100%). I) Stimulation at 6 Hz, 1 V: a) during stimulation, b) after stimulation; II) stimulation at 60 Hz, 2 V: a) during stimulation, b) after stimulation. Black column denotes positive deflection; white column amplitude of background EEG; obliquely shaded column, heart rate; cross-hatched column, respiration rate. Region of stimulation shown diagramatically above.

The investigations thus showed that both facilitatory and inhibitory influences on PRs of the visual cortex can be obtained from the same points in different parts of the anterior hypothalamus, depending on the character of stimulation. As a rule, the PR facilitation reaction was stronger than the inhibition reaction. This was shown by the fact that the facilitation effect remained, and was actually increased, after discontinuing hypothalamic stimulation, while the inhibition effect on the PR was observed mainly during stimulation. The strongest influence of the hypothalamus on PRs in the visual cortex, with respect to both facilitatory and inhibitory effects, was observed during simultaneous changes in the frequency and voltage of electrical stimulation. Changes in frequency only led to a decrease in these effects without changing their character. This can be regarded as evidence of spatial demarcation of the hypothalamic neuronal structures responsible for the two effects on the cortex.

The absence of any definite parallel between changes in PR and autonomic indices during stimulation of the anterior hypothalamus confirms the existing view that its ascending and descending influences have different mechanisms.

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