AN EXPERIMENTAL MODEL FOR THE STUDY OF THE INTERACTION BETWEEN THE CEREBRAL CORTEX AND SUBCORTICAL FORMATIONS

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Experiments on rats have shown [11, 18] that the region of the hypothalamus bears a definite relationship to the food reaction. When this region is injured appetite is increased, the food intake rises, and the animal develops obesity.

Other researches carried out on rats, cats, and monkeys [7-10, 13, 15, 16], have demonstrated the differential role of the various parts of the hypothalamus in the food reaction. For instance, the function of stimulation of the food reaction has been attributed to the anterolateral nuclei of the hypothalamus. Stimulation of this part of the hypothalamus led to its hyperfunction, expressed by a marked increase of appetite. Injury to or destruction of these nuclei caused a depression or loss of their function, with a corresponding decrease of appetite. Stimulation of the ventromedial nuclei, on the other hand, caused a decrease of appetite, and injury to these nuclei or their destruction led to an increase of appetite and food intake [12, 14, 17].

One of the objects of the present research was to study the interaction between the centers of the conditioned and unconditioned food reactions during direct electrical stimulation of the subcortical food center in the region of the hypothalamus.

The other object was to investigate the role of the subcortical centers in the mechanism of certain manifestations of the neurotic state. In particular, we were interested in the mechanism of the animal's refusal to take food in experimental neurosis and in the participation of the subcortical centers of the food reaction in this phenomenon. In this case we attempted to ascertain whether the animal's food behavior in a state of experimental neurosis could be modified by direct electrical stimulation of the anterolateral division of the hypothalamus, responsible for the function of stimulating the food reaction.

EXPERIMENTAL METHOD

The work was conducted on two dogs with electrodes permanently implanted in the anterolateral part of the hypothalamus. The electrodes were made of nichrome wire (diameter 50-100 μ) insulated with enamel. For convenience of insertion and for better insulation, the tip of the wire for a distance of 22-25 mm was contained in a fine glass capillary tube, and inserted as a needle under visual control through the corpus callosum to the required depth [3]. Bipolar stimulation with rectangular pulses (frequency 20-50 cps, duration of pulse 5-20 millisec) was used, and the output voltage was up to 5-6 V. The stimulating current was supplied by a GRAKh stimulator. Stimulation lasted for 30-60 sec. The experiments began not less than 20-25 days after the operative implantation of the electrodes.

EXPERIMENTAL RESULTS

Before embarking on the main experiments, in two dogs we carried out a series of experiments in order to verify previous reports of the presence of a center in the anterolateral division of the hypothalamus stimulating the food reaction. In order to obtain a more reliable effect of stimulation of the hypothalamus, before the experiment the animals were fed to satiation on the same diet as was later given during the experiment. In the dog Agap, stimulation of the anterolateral division of the hypothalamus after complete satiation caused an increase in food excitability, and the dog ate twice to three times as much food as in an ordinary experiment without satiation.

The increase in food excitability was particularly demonstrative and clearly defined in the experiments with

the dog Mal'chik. From 10 to 30 sec after the beginning of stimulation of the anterolateral division of the hypothalamus, the satiated animal began to eat the food which had been there all the time and which had hitherto been refused; at the end of stimulation the dog immediately ceased to eat. In the same experiment these stimulation tests were repeated 5 or 6 times, always with the same effect of increasing the food excitability, although during the last tests the latent period of the food reaction was lengthened or it became necessary to increase the strength of stimulation. The effect of an increase in the food excitability as a result of stimulation of the hypothalamus could be inhibited if another dominant was present in the central nervous system. The dog Mal'chik, for example, if left alone in the room, always became excited, and against this background stimulation either showed no effect or its effect was inconstant (for this reason the experimenter's assistant always remained in the room during the experiment). The effect of stimulation was also inhibited if the animal was strapped, i.e., by the presence of a freeing reflex.

In the experiments on the dog Mal'chik (with developed conditioned food reflexes and permanently implanted electrodes in the deep food center) we attempted to ascertain the influence of stimulation of the subcortical food center on conditioned reflex activity.

In the first part of the experiments we found that the application of stimuli to the anterolateral part of the hypothalamus led to a general deterioration in the conditioned reflex activity. This fact is in agreement with the observations of other workers [1, 2, 6]. To study this phenomenon further, in a special series of experiments we stimulated the subcortical food center at the moment when the positive conditioned stimulus was acting alone. Stimulation started 3-5 sec after the beginning of the action of the conditioned stimulus and continued until the feeding bowl was offered or for a period of 5-20 sec in conjunction with the action of the unconditioned food stimulus. Sometimes the stimulation of the hypothalamus started earlier, and after it had been applied for 5-10 sec the conditioned stimulus was applied.

The results of these experiments showed that in response to the combined action of direct electrical stimulation of the subcortical food center and the conditioned food stimulus the magnitude of the positive conditioned reflexes was diminished. If, however, the subcortex was stimulated, the dog took food readily as before, the moment the conditioned stimulus was reinforced.

The simultaneous development of the process of excitation at two levels of the complex structure of the food reaction apparently led to the inhibition of the weaker focus of excitation, for direct electrical stimulation of the subcortical center, causing very powerful excitation, produced a correspondingly stronger inhibition of the cortical reaction by a mechanism of simultaneous negative induction.

The next state of the work with the dog Mal'chik was to discover whether it was possible, by direct electrical stimulation of the subcortical food center, to modify the food behavior of the animal when disturbed as a result of experimental neurosis. A neurotic state was induced in the dog by means of conflicts and excessively strong stimuli, and it continuously refused to eat. Stimulation was then applied to the anterolateral division of the hypothalamus. In this case, too, in a state of marked neurosis direct stimulation of the subcortical food center had the same effect as in the preliminary experiments. The dog, which hitherto had refused its food, began to eat during stimulation of this center. However, in order to produce a food reaction in this case a current of higher frequency was required than in the experiments with satiation before the induction of the experimental neurosis (40-50 cps during neurosis compared with 20 cps before neurosis), while all the other parameters of the stimulating current remained unchanged.

Hence, experiments on dogs with implanted electrodes demonstrated the presence of a center for the food reaction in the anterolateral division of the hypothalamus, stimulation of which by means of an electric current led to a marked increase in food excitability.

The complexity and difficulty of the study of the effect of the unconditioned reflex on conditioned reflex activity may be explained, inter alia, by the lack of a suitable technique, despite the remarkably wide range of methods described in the literature. Methods of stimulation [4, 5, 6] and destruction [1, 2] of the various subcortical centers have been used most extensively. Their failing is that no direct functional connection was usually present between the stimulated or destroyed subcortical regions and the cortical activity under investigation. It was only in those cases in which the effect of stimulation or destruction of the strio-pallidary system (bearing a definite relationship to the motor reactions) on the conditioned motor-defensive reflexes was studied that this method proved more or less adequate.

In this respect our own experimental model is more adequate, for we investigated the effect of stimulation of the subcortical food center on the conditioned reflexes developed on the basis of the food reactions, i.e., we studied the interaction between the cortical and subcortical centers joined by the mechanism of a temporary connection and functioning as a single entity.

The possibility of acting directly on the center of the unconditioned food reflex through implanted electrodes in an animal with developed conditioned food reflexes must contribute to the understanding of one of the specific aspects of the complex problem of the interaction between the cerebral cortex and the subcortical formations.

SUMMARY

Electric stimulation of the anterolateral hypothalamic area in 2 dogs with implanted electrodes provoked a marked rise in food excitability. The animal ate even when it was completely full.

Direct stimulation of the subcortical food center in the hypopthalamic area temporarily eliminated one of the characteristic symptoms of experimental neuroses – the animal's refusal to eat. Electrode implantation into the subcortical food center in the hypothalamic area of the animal with food conditioned reflexes was regarded as an adequate model for studying the interrelations of the brain cortex and subcortical formations.

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