THE EFFECT OF STIMULATION OF GASTRIC MECHANORECEPTORS ON CONDITIONED MOTOR ACTIVITY IN RATS

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In the past ten years various aspects of the problem of interoception have been subjected to intensive experimental investigation. In spite of this fact, very little is known about the role of interoceptive signalling in the formation of an animal's behavior.

Through his studies of cerebral cortical regulation of processes that occur in the internal organs, K. M. Bykov [2] arrived at the conclusion that "functional interoceptive fields created in the cortex are sometimes powerful factors in the formation of behavior."

V. N. Chernigovskii [5] showed that under certain conditions, interoceptive impulses exert excitatory and inhibitory effects on the activity of the skeletal musculature, which is the effector of any behavioral act. In addition, these authors have established that the extent to which interoceptive impulses affect the musculature depends on the state of the organism's internal environment.

In studying the effect of interoceptive stimulation on the act of eating, I. P. Bel'skaya [1] showed that this activity is depressed when the stomach fills. Moreover, this depression depends, not on the weight of the stomach contents, but on the extent to which the walls of the stomach are stretched.

Janowitz and Grossman [6] also observed a change in food intake in dogs upon insertion of food or an indifferent object (a rubber balloon) into the stomach through a fistula.

M. A. Usievich [4] indicated that over-all alimentary behavior shows a definite dependence on the extent of gastric stretching by food or a rubber bag.

A. M. Ugolev and V. N. Chernigovskii [3] showed in experiments on rats that the receptors of the alimentary canal mainly determine the feeding rhythm, and to a lesser extent, the 24-hour consumption of food and fluids.

But as far as we know, no one has yet made a separate study of the influence of the interoceptors on the motor reaction of animals under free-behavior conditions. The purpose of the present study was to investigate the effect of interoceptive stimulation of the stomach on alimentary motor conditioned reflexes in rats.

METHODS

Motor conditioned reflexes were developed in white rats, weighing from 120 to 160 g, in a cage with two feeding trays (see figure).

As may be seen from the figure, the cage is a T-shaped maze in which there are two feeding trays (B and C) and a starting point (A), where the rat stays in the intervals between applications of the conditioned stimuli. Pieces of cooked meat were used as unconditioned stimuli, and were placed in feeding trays B and C. The conditioned stimulus was a flashing light or the sound of a buzzer.

In the initial stages of the development of differentiation between the two sides of the cage on the basis of reinforcement, we observed a positive reaction to the application of both the buzzer and the light in the direction of either feeding tray, independently of the quality of the conditioned stimulus. But since the motor conditioned reflex was reinforced only on one side at the sound of the buzzer and only on the other when the light was flashing, the rats subsequently developed motor differentiation of the sides of reinforcement: The sound of the buzzer was accompanied by a positive motor reaction toward the left feeding tray, and the flashing light by a positive reaction toward the right tray. After eating the food, the rat returned to the starting point in the maze (point A).

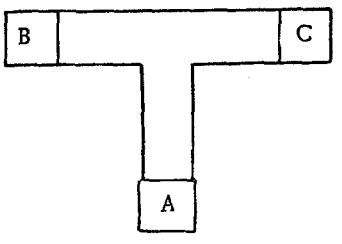

Diagram of cage with two feeding trays (B and C), for producing motor conditioned reflexes in rats.

TABLE 1. Production of a Motor Conditioned Reflex and of Differentiation of the Sides of Reinforcement.

No. of rat	Development of motor conditioned reflex (number of trials)	Development of differentiation of sides of reinforcement (number of trials)	Wrong choices (%).
1	16—18	35—38	10
2	14—15	29—30	5
3	15—16	32—33	10
4	17—18	35—37	10
5	12—14	40—42	5
6	19—20	47—50	10
7	14—16	30—32	10

Mechanoreceptors were stimulated by stretching the walls of the stomach with a rubber balloon. Gastric fistulas had previously been created in these rats, and a small rubber balloon was later inserted through the fistula.

After stable differentiation of the sides of reinforcement had developed, a series of experiments involving stimulation of the gastric mechanoreceptors was carried out. The feeding activity of the animals was tested before each experiment. Experiments were performed only when the animal readily ate the pieces of meat. During the experiment the animal was in the maze with the inflated balloon in its stomach; then the balloon was removed, and after 10-15 minutes the motor alimentary reaction was tested again.

In order to answer several questions that arose in the course of the work, a series of experiments was carried out on rats that were first vagotomized subdiaphragmatically.

RESULTS

In the majority of the rats, a motor conditioned reflex appeared after 14-16 trials and became more stable after 25-27 trials. The rate at which differentiation developed was different in different rats. After stable differentiation had developed, the rats were sometimes observed to run to the wrong feeding tray, but the percentage of wrong choices of the side where reinforcement would occur was not greater than 10. Table 1 shows the results of experiments on the production of conditioned reflexes and differentiation in seven rats that were subsequently used for studies of the effects of gastric mechanoreceptors on motor alimentary activity.

Experiments conducted while the wall of the stomach was distended by the balloon showed that the percentage of wrong choices did not change greatly—i.e., differentiation of the sides of reinforcement was not disturbed. It should be pointed out that at the end of the experiment, 30-40 minutes after insertion of the balloon into the stomach, the rats were less active: they returned to the starting point without ever reaching the food. This lessening of activity could not be explained as the result of fatigue during the experiment, since rats in which the balloon was not inserted were active throughout the entire experiment. Thus, in experiments where the gastric mechanoreceptors were stimulated, all seven rats consistently refused to eat:When they came close to the food, they suddenly returned to the starting point; whereas 15-20 minutes after the balloon was removed, they again readily devoured the pieces of cooked meat.

We may conclude that the application of the conditioned signal against the background of inflation of the balloon in the stomach does not materially alter conditioned-reflex activity: The conditioned motor reflexes and differentiation of the sides of reinforcement are retained. But it is interesting that the animals reject food that is offered.

We may suppose that stimulation of gastric mechanoreceptors for 30-40 minutes is accompanied by a reduction of alimentary excitability, and the animals' reaction outwardly resembles the behavior of animals in a satiated condition.

Insertion of a balloon into the stomach cavity has other effects besides stimulation of gastric mechanoreceptors. We have not ruled out the possibility that other effects besides those directly related to stimulation of these receptors are taking place. To test this, we ran a series of experiments with subdiaphragmatic vagotomy.

Six rats received preliminary subdiaphragamatic vagotomies. As in the previous series of experiments, conditioned motor reflexes and differentiation of the sides of reinforcement were developed in these rats.

In the series of experiments involving stimulation of gastric mechanoreceptors, it was found that differentiation of the sides of reinforcement was not greatly disturbed—i. e., the percentage of wrong choices did not increase. But in the vagotomized rats, stimulation of the gastric mechanoreceptors by inflating the rubber balloon did not result in lowering the animals' appetite for food. Whereas distention of the stomach wall causes unoperated rats to refuse to eat, the same stimulus applied to operated rats is accompanied by active ingestion of cooked meat.

In another series of experiments on five rats, conditioned motor reflexes were developed, and also stable differentiation of the sides of reinforcement. In this case, distention of the stomach by the balloon was accompanied

TABLE 2. Feeding Behavior and Conditioned Motor Reflexes in Rats Before and After Subdiaphragmatic Vagotomy

No. of rat	Before denervation of stomach		After denervation of stomach	
	wrong choices (%)	feeding behavior with stomach distended	wrong choices (%)	feeding behavior with stomach distended
24	10	Refused to eat	10	Ate actively
25	10	The same	10	Ate actively
26	10	The same	15	Ate actively
27	10	The same	10	Ate listlessly
28	5	The same	10	Ate actively

by complete refusal to eat, but the percentage of wrong choices was not greater than 10.

After these figures had been obtained, the rats were subjected to subdiaphragmatic vagotomy – i. e., vagotomy was performed after conditioned reflexes and differentiation were developed.

As is evident from Table 2, experiments carried out 4-5 days after operation showed that while the inflated balloon is in the stomach, conditioned reflex activity is essentially unaltered. These rats ate the food presented, and returned to the starting point in the cage.

SUMMARY

This paper deals with studies of the effect of stimulation of gastric mechanoreceptors on components of the complex conditioned motor food reflex. It was demonstrated that not all components of this reaction were disturbed by stimulation of gastric mechanoreceptors, but only those associated with the act of food ingestion. This indicates that the influence of the mechanoreceptors is not diffuse, but specialized. It was shown experimentally that higher nervous activity was not appreciably changed in the rats investigated, whereas the act of ingestion itself was inhibited in all these animals.

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