ON THE ROLE OF THE CEREBRAL CORTEX IN THE FUNCTIONAL INTERRELATIONSHIPS BETWEEN THE MAMMARY GLAND AND THE DIGESTIVE SYSTEM

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Many investigators have studied the reflex interrelationship between the mammary gland and the digestive system. It was established [4, 5, 6] that stimulation of receptors in the mammary gland can easily cause the reaction of regurgitation and a second rumination of the food. Subsequently, some new and analogous data were obtained [1, 2, 3, 7-11]; in particular, they demonstrated the significance of cortical stimuli from the nipple in the appearance of the rechewing reflex [5, 6]. However, up until now it has remained unclear what action is exerted by the impulses from the mammary gland receptors on the activity of the various divisions of the digestive system, and whether these influences could be accomplished via a conditioned reflex mechanism.

The purpose of this work was to investigate the role of the cerebral cortex in the functional interrelationships between the mammary gland and the various divisions of the multichambered stomach.

EXPERIMENTAL METHODS

The experiments were carried out on 3 goats, on a long term basis. First, fistulae were surgically connected to the rumen, reticulum, omasum and abomasum. The motor activity of the multilocular stomach was recorded with the aid of a rubber balloon, inserted through the aperture of the fistula in the cavity of each portion of the stomach, and connected with Marei capsules. Transmission of the water- air type was used. The rechewing reflex was recorded according to the method developed by I. I. Grachev [4]. Recording of the masticatory movements was carried out on a kymograph drum, using a balloon attached to the lower jaw of the goat. The conditioning stimulus was the sound of an electric bell, and the direct stimulus was mechanical stimulation of receptors in the mammary gland (60-70 compressions of the nipple per minute). The bell was switched on 5-15 seconds before mechanical stimulation of the mammary gland receptors was begun. The conditioning stimulus was stopped with termination of the direct one. Combination of the two stimuli was repeated every 5-10 min, for a total of 4-7 combinations per trial. The formation of the conditioned reflex reaction was evidenced by the appearance of chewing, and changes in the frequency and intensity of the contractions in the different divisions of the multilocular stomach without application of the direct, mammary gland stimulus. For the development of differentiation, we used a sound signal – a buzzer, weaker in intensity than the positive stimulus. The experiment were carried out during the morning hours in an isolated room. The animal was placed in a stand specially prepared for small, fistulated animals, and adapted for recording the contractions of all divisions of the multichambered stomach.

EXPERIMENTAL RESULTS

When the mammary gland receptors were stimulated, the contracting activity of all divisions of the multilocular stomach intensified (Fig. 1). Within 5 seconds after stimulation was initiated, an additional contraction wave appeared in the reticulum, the contents of the forestomachs were regurgitated into the oral cavity, and the secondary chewing of the food began. Subsequently, contraction occurred in the omasum, rumen and abomasum, in that order. The contractile function was increased by 2-4 contractions in 5 min, and the intensity of the individual contractions was elevated. It should be noted that the nature of the contractions in the reticulum was altered: with stimulation of the mammary gland receptors, they changed from biphasic to triphasic. The additional phase is apparently

related to regurgitation of the cud; in this case, the initial contraction of the reticulum was considerably weaker. When stimulation of the mammary gland receptors was stopped, the frequency of contractions in all divisions of the stomach returned to the original level after 20-40 sec.

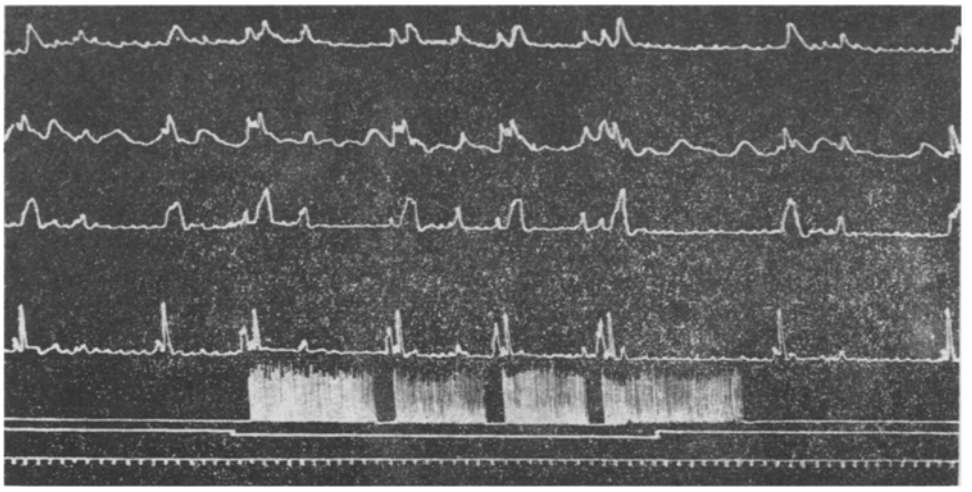

Fig. 1. Contraction of the rumen, reticulum, omasum, and abomasum during mechanical stimulation of the mammary gland receptors. Meaning of the curves (from above downward): contraction of the abomasum, omasum, rumen, reticulum; chewing motions; stimulation marking and time markings (5 sec).

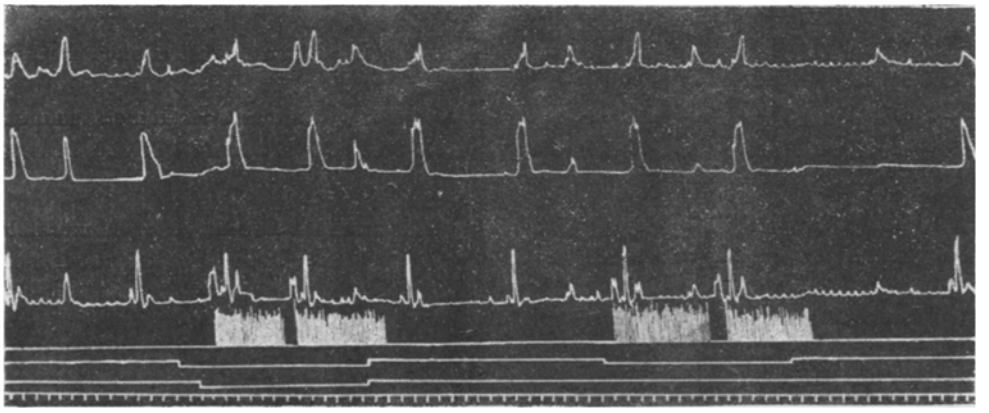

Fig. 2. Formation of the conditioned cud-chewing reflex, and conditioned reflex changes in the motor activity of the multichambered stomach. Meaning of the curves (from above downward); contraction of the abomasum, rumen, reticulum; chewing motions; marking of the conditioned and direct stimulus, and time markings (5 sec).

In the first experiments, the sound of the electrical bell, as a new stimulus for the goats, inhibited the contraction of the multichambered stomach. This was clearly apparent from the behavior of the animal, and the increase in the latent period of the reflex reaction.

Development of the conditioned reflex reactions involving the contractile activity of the multichambered stomach varied among the different animals. In the goat, Astra, the conditioned reflex formed after 26 stimulus combinations (Fig. 2). With the action of only the conditioned stimulus (without mechanical stimulation of the mammary gland receptors), the contraction frequency increased in all divisions of the multichambered stomach, and a cud appeared, similar to that observed with mechanical stimulation of the mammary gland receptors (Fig. 3).

The first conditioned reflex cud chewing and reaction on the contractile activity of the multichambered stomach in the goat, Belyanka, was seen on the 24th combination, while in Moshka on the 38th. In this case, the first conditioned reaction was unstable, but the reaction subsequently grew stonger: in Astra – after 48, in Belyanka – after 60, and in Moshka – after 83 combinations. Thus, the rate of formation and fixation of the conditioned reflexes in the different goats was not the same, which is apparently related to individual peculiarities of the nervous system.

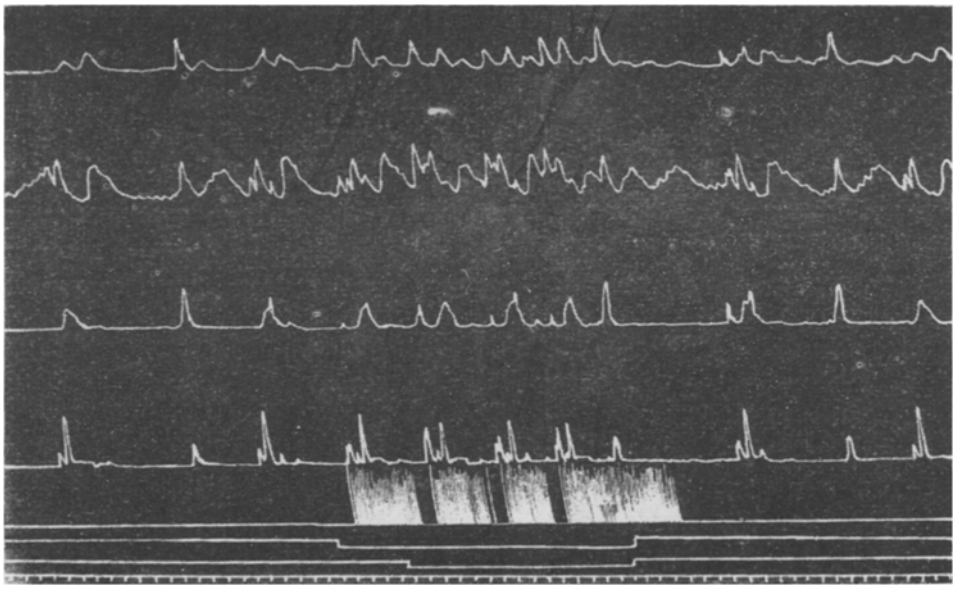

Fig. 3. Conditioned motor reaction of the digestive apparatus of ruminents. Meaning of the curves is the same as in Fig. 1, with the addition of markings for the conditioned stimulus (6th line).

Extinguishing of the Conditioned Reflex Motor Reactions in the Multichambered Stomach of the Goat, Astra

Time	Presence of cud-chewing reflex	Number of contractions in 5 minutes				Latent period of the cud-chewing reflex
		rumen	reticulum	omasum	abomasum	
Starting level		10	7	14	13	
With reinforcement	Yes	13	9	17	17	6
Without reinforcement:						
10 hours	Yes	12	8	15	14	8
10 " 10 min	"	13	9	15	15	8
10 " 20 "	"	12	9	16	15	14
10 " 30 "	"	13	10	17	16	24
10 " 40 "	"	11	8	16	14	18
10 " 50 "	"	12	8	17	14	30
11 "	No	9	7	13	13	–
11 " 10 min	"	10	8	13	13	–
11 " 20 "	"	8	6	12	11	–

The sharp extinguishing of the conditioned reflex reactions involving cud-chewing and the contractile function of the rumen, reticulum, omasum and abomasum, also occurred with differences in the different goats: in Astra (see table) (after 6) and in Belyanka and Moshka (after 4) stimulations that were not reinforced with the sound signal (in the course of one run).

After extinguishing, the conditioned reflex reaction was restored after 3-5 reinforcements.

In developing differentiation of the negative sound signal, the conditioned reflex reaction of the goats, in the first combinations, was the same as for the positive stimulus. The differentiated conditioned reflex, involving the cud-chewing and changes in the contraction of the rumen, reticulum, omasum and abomasum, did not clearly occur until after 18-30 applications of the differentiating stimulus, and was not fixed until after 35-60 stimulations. New external stimuli (auditory, visual, cutaneous), acting at the moment of application of the conditioning signal, inhibited the reflex reaction. Thus, for example, in the presence of great noise or with the appearance of an unfamiliar person, the developed conditioned reflexes disappeared in the animal. The conditioned reflex reaction only began several seconds after removal of the external stimuli.

Sometimes, in the experimental animals, cud-chewing and intensification and acceleration of the contraction in all portions of the multichambered stomach began inside the experimental chamber, even prior to stimulation of the mammary gland receptors, for example, with the appearance of the person who milks the goat, or when the vessel for the milk was brought in. This indicates that the cerebral cortex plays an important role in the functional interrelationships between the mammary gland and the digestive system; the cortex not only influences the activity of the individual internal organs of ruminent animals, but also regulates their functional interrelationships.

SUMMARY

The contractile function of all the portions of the multilocular stomach of ruminants enhances in stimulation of the gland receptors. Phenomena of external inhibition of the mentioned reactions were revealed. By combining mechanical stimulation of the mammary gland receptors with conditioned sound stimulus (bell) it was possible to obtain conditioned reflex changes of the contractile function of the reticulum, paunch, omasum and abomasum. The mentioned reactions are subject to extinctive and differential inhibition. Consequently, an important role in the functional interrelation of the mammary gland and digestive system belongs to the cortex of the large cerebral hemi spheres.

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