

MATERIAL FOR A STUDY OF THE INFLUENCE OF STIMULATION  
OF THE DIGESTIVE TRACT INTEROCEPTORS ON THE  
UNCONDITIONED DEFENSE REFLEXES

COMMUNICATION II. INFLUENCE OF STIMULATION OF THE MECHANORECEPTORS OF THE  
GASTROINTESTINAL TRACT ON THE DEFENSE REFLEX IN VARIOUS FUNCTIONAL STATES  
OF THE CEREBRAL CORTEX

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The influence of the higher regions of the central nervous system on interoceptor reflexes has been shown in the works of V. N. Chernigovsky [7] and V. A. Lebedeva [3]. They found that decerebration of animals leads to an intensification of the interoceptor reflexes. G. A. Kovaleva [2] established experimentally that with electrical and chemical stimulation of the individual parts of the cerebral cortex a significant decrease in receptor reflex influences on respiration and arterial pressure is noted. O. S. Merkulova [5] discovered that functional exclusion of the cerebral cortex causes a deepening of the inhibitory "righting" influences on the skeletal musculature with stimulation of the interoceptors. All these experiments were conducted in acute tests.

In the given investigation, in long-term experiments on dogs, the influence of the functional state of the higher regions of the central nervous system on interoceptor reflexes was studied. For this purpose the functional state of the higher regions of the central nervous system in the experimental animals was modified and recordings made of the changes occurring under these conditions in the interoceptor influences of the mechanoreceptors of the gastrointestinal tract on the defense (flexor) reflex. The observations were made on the dogs Nochka and Elka on an isolated convolution of the small intestine, according to Tir-Bella, and on the dog Sharik with a fistula of the stomach, according to Basov.

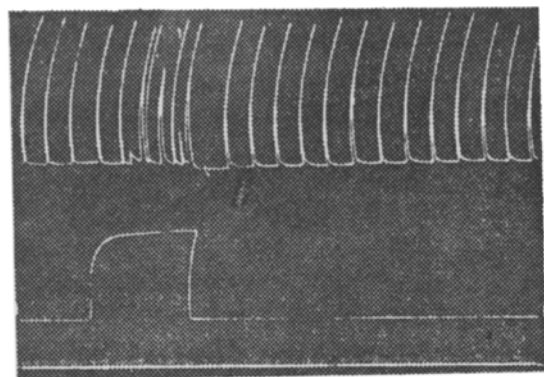
Influence of a Powerful Stimulus

In the first series of experiments in order to modify the functional state of the higher regions of the central nervous system in the experimental dogs such a powerful and natural stimulus was employed as teasing (sight of a cat).

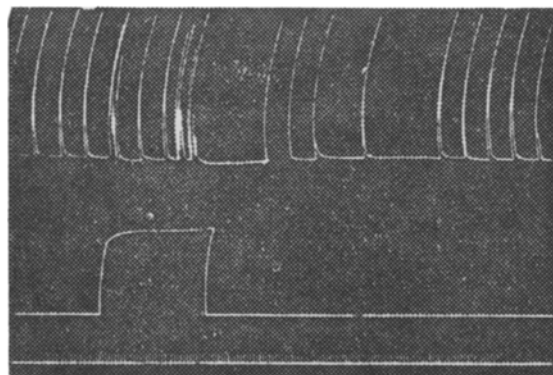
The investigation was conducted according to the following plan: in the first (control) half of each experiment a graphic recording was made of the defense reflex in an animal, caused by a rhythmic (every 15 seconds) electrical stimulus of the skin of the hind limb. Against the background of the steady reflex movements of the limb in the dogs under experiment, the stomach or intestinal convolution was inflated for 2 minutes.\* Then there was a 10 minute break. The second half of the experiment commenced with the teasing of the animal. After this the recording was repeated, fully observing the conditions employed in the method for the control experiment.

In the control investigation on the dog Nochka it was established that on inflating the isolated portion of the small intestine there was recorded a general motor reaction and an insignificant inhibition of the defense reflex seen in the omission of a single contraction and decrease in the amplitude of the reflex movements (Fig. 1, A.). After teasing absence of some of the reflex movements of the limb was apparent (Fig. 1, B).

\* According to method of electric stimulation of the skin, recording of the defense reflex and also of the dosage stimulation of the mechanoreceptors. See Communication 1 [4].



A



B

Fig. 1. Change in the interoceptor influences of the small intestine on the defense reflex with an emotional stimulus. Expt. No. 125, August 2, 1950. A) Control; B) after teasing with a cat. In the experiment is noted an intensification of the inhibitory righting influences. Significance of the tracings (reading from top to bottom): movement of the left hind leg in response to electrical stimulus (distance between the coils of the induction apparatus—10 cm); tracing of stimulation of small intestine (pressure 120 mm mercury); time interval in seconds.

This testified to the intensification of the inhibitory righting influences of the mechanoreceptors of the intestines. The same intensification effect of the inhibitory influences was found in the dog Elka and the dog Sharik.

In a series of tests conducted on the dog Sharik, as a result simply of teasing without inflation of the stomach there was seen an inhibition of the defense reflex. The restoration of the defense reflex occurred with an increase in the strength of the electric current, applied in order to stimulate the skin of the hind limb.

#### Effects of Bromides and Caffeine

In the subsequent investigations the functional state of the cerebral cortex in the dogs was modified by the help of pharmaceutical preparations—bromides and caffeine.

The experiments with caffeine were devised along the following lines: before administration of caffeine the control experiment was conducted. Upon its termination the dogs were subcutaneously injected with 10% solution of caffeine (caffeine sodium benzoate). 30-40 minutes after injection of caffeine the test was

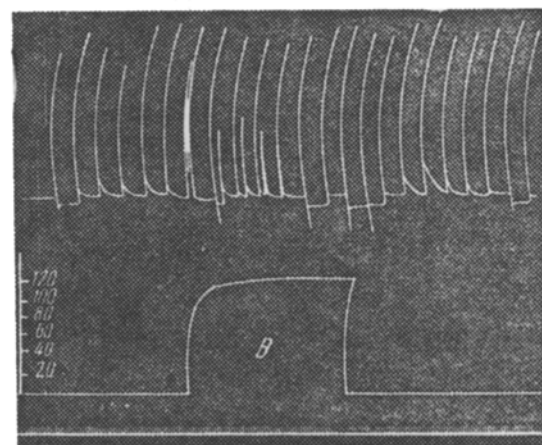
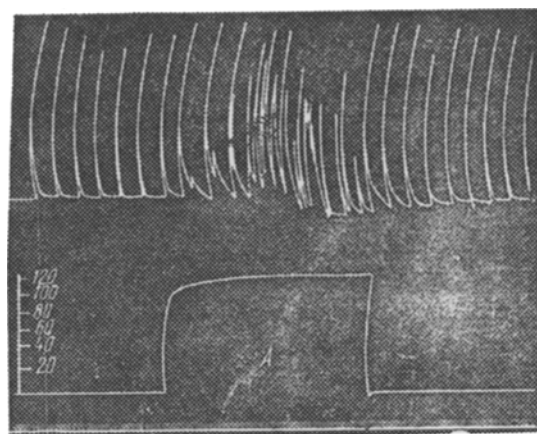


Fig. 2. Changes in the interoceptor influences of the small intestine on the defense reflex after administration of caffeine. Experiment No. 126 of August 4, 1950.

A) Control: corresponding to inflation—a general motor reaction, moderate inhibition of the defense reflex; B) 17 minutes after administration of 1 ml 10% solution of caffeine: absence of inhibitory influences of the mechanoreceptors of the small intestine on the rhythm of the reflex activity. Distance between coils of induction apparatus, 9 cm. Significance of tracings as in Fig. 1.

repeated with an exact reproduction of the control. An inhibition of the defense reflex was usually observed on inflating the stomach of dog Sharik in the control. Following injection of 1 ml 10% solution of caffeine an intensification of the inhibitory influences of the mechanoreceptors of the stomach on the defense reflex was noted.

In the dog Nocka in the control part of the experiment with inflation of the intestinal convolution (120 mm mercury) a general motor reaction and an insignificant inhibition of the defense (flexor) reflex was observed (Fig. 2, A). After introduction of 1 ml 10% solution of caffeine the behavior of the dog changed perceptibly. It did not react to calls, the eyes were immobile and open, head raised, active movements absent. In this state of the animal inflation of the intestinal convolution (120 mm mercury) did not cause inhibition of the defense reflex nor the general motor reaction which was observed in the control experiment before administration of caffeine (Fig. 2, B). After an interval of one week the caffeine dosage injected in the dogs was reduced to 0.5 ml. After injection of the reduced dose of caffeine, on inflating the isolated convolution of the small intestine (120 mm mercury) a general motor reaction with a subsequent inhibition of the reflex movements of the limb was observed.

We also studied the effect of a cumulation of bromide in the organism of the dog on the interoceptor reflexes. The dog Sharik, which had a fistula in its stomach, was given 1 g sodium bromide daily for 10 days. In order to exclude the stimulating effect of bromide salts on the mucosa of the stomach, the bromide salt was given 18 hours before the test.

The tests were conducted as follows: the previous evening the dog was given food together with sodium bromide. In the morning the empty stomach was rinsed with hot water (36-37°) and 10-15 minutes later the graphic registration of the defense reflex commenced. Alongside the induced reflex contractions, the stomach was inflated for two minutes with a thin-walled rubber bulb at a pressure of 40 mm or 80 mm mercury. Recordings were made for 3 days before administration of the sodium bromide, then for 10 days during the period of its absorption and for 20 days after withdrawal of the bromide.

During the period of bromide administration and at the end of it, non-monotypic changes in the defense reflex on inflating the stomach of the animal were observed. Most frequently observed was an insignificant inhibition of the defense reflex, in relation to that usually seen in the control experiment before the effect of the bromide.

Sometimes stimulatory influences were noted on inflating the stomach. Thus, on the fifth day of administration of sodium bromide, on inflating the stomach (40 mm mercury), an insignificant inhibition of the defense reflex was seen; with application of a more powerful stimulus of the mechanoreceptors of the stomach (80 mm mercury) there occurred a stimulation of the defense reflex. On the sixth day of the action of the bromide salt there was observed a vivid paradoxical reaction when, on inflating the stomach with the lower pressure (40 mm mercury), there occurred a sharp inhibition of the defense reflex (Fig. 3, A) and, on inflating the stomach with the higher pressure (80 mm mercury), a stimulation of the defense reflex was observed at the moment of inflation (Fig. 3, B).

On the ninth day of administration of sodium bromide, on inflating the stomach (40 mm mercury), stimulation of the defense reflex was noted and, with a pressure of 80 mm mercury, inhibition of this reflex. Now and then the stimulation effect on inflating the stomach was observed after withdrawal of the bromide.

In some cases distinctly marked inhibitory influences on the defense reflex were observed both in the period of bromide intake and after its withdrawal. Only in isolated cases did the inflation of the stomach fail to affect the reflex activity studied.

Intake of sodium bromide in the second dog, Elka, with an isolated intestinal convolution, lasted for 10 days. The dog received each day, 18 hours before the test, 0.25 g sodium bromide.

The reduced dose in comparison with the first dog was due to the fact that, according to our observation, the dog Elka possessed a relatively weak nervous system with a marked inhibitory reaction to powerful, unexpected and new stimuli.

In a large number of tests in the control experiment carried out before administration of the bromide to the dog Elka no perceptible changes in recorded reflex activity were found on inflating the isolated intestinal convolution at a pressure of 80 and 120 mm mercury.

In the bromide treatment process there was seen a manifestation of moderately expressed inhibitory influences of the mechanoreceptors of the small intestine upon application of an adequate stimulus (inflation) on the defense reflex, induced by electric stimulation of the hind limb of the dog.

From the above it follows that modification of the functional state of the higher regions of the central nervous system (with teasing, and the effect of bromide and caffeine) exerts a distinct influence on the interoceptor reflexes.

On the basis of the analysis of the data obtained, the following deductions can be made about the mechanism of changes in the interoceptor reflexes in these conditions:

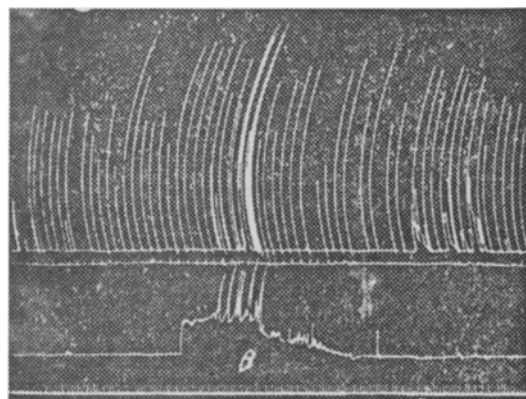
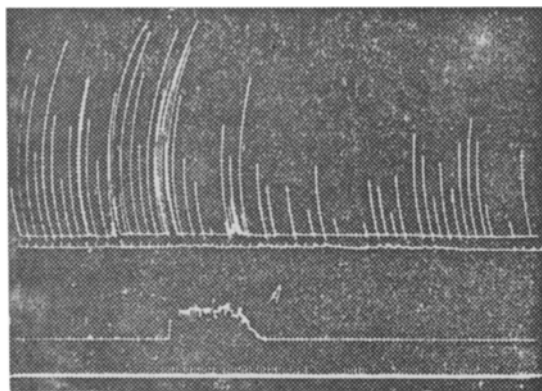


Fig. 3. Change in the interoceptor influences of the stomach on the defense reflex under the influence of sodium bromide. Experiment No. 155 of December 30, 1950.

A) With inflation of the stomach at a pressure of 40 mm mercury inhibition of the defense reflex is noted;  
B) with inflation of the stomach at a pressure of 80 mm mercury a stimulating influence on the defense reflex is noted when the wave-like contractions are replaced by momentary inhibitory influences. Distance between coils of induction apparatus 8 cm. Significance of the tracings, reading from top to bottom: movement of the hind left limb; indication of electrical stimulation of the skin of the hind left limb; stimulation of the mechanoreceptors of the stomach; time interval in seconds.

The appearance of stimulating influences on the defense reflex on stimulating the mechanoreceptors of the stomach, must apparently be related to the intensification and concentration of the process of internal inhibition in the cortex of the large hemispheres under the influence of the bromide. With this it is necessary to note that the stimulating influences did not appear at once but after several days. According to L. M. Georgievskaya and M. A. Usievich [1] and M. K. Petrova [6], the manifestation of the effect of bromide on the higher nervous activity of the animal requires that it be administered for several days at a time in order that the determined concentration is reached by accumulation.

The intensity of the inhibitory influences of the mechanoreceptors of the gastrointestinal tract on the defense reflex in dogs, with excitation (teasing) and after introduction of caffeine must obviously be explained by the intensity of the stimulating process in the cerebral cortex.

Our investigations lead one to conclude that the interoceptor influence of the mechanoreceptors of the stomach and intestinal tract on the defense reflex are dependent on the functional state of the cerebral cortex. It was shown by us that the excitation of the dog intensifies the inhibitory righting influences of the mechanoreceptors of the gastrointestinal tract on the defense reflex, and that administration of caffeine in dogs either intensifies or weakens these influences, depending on dosage. It was also established that administration of bromides in dogs spread over 10 days causes distinct change in the interoceptor reflexes.

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\* In Russian.

\*\* Original pagination. See C. B. translation.