INTERACTION BETWEEN ANALYZERS DURING ADEQUATE STIMULATION OF THE VESTIBULAR APPARATUS OF THE DOG

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Investigations [1, 4] have shown that by changing the functional state of the optic and proprioceptive analyzers it is possible to strengthen or inhibit vestibular reactions. The object of the present study was to investigate the motor activity of the stomach during adequate stimulation of the vestibular apparatus at a time when the interaction between the analyzers was disturbed, and to examine the role of this motor activity in the genesis of motion sickness.

METHOD

The effect of alternating linear acceleration, arising during displacement of the body in the vertical plane, on the motor function of the stomach was studied in the presence of complete (oscillating in darkness) or partial (oscillating in an illuminated chamber with a covered source of light, preventing flickering of objects) exclusion of the optic analyzer. The influence of the proprioceptive analyzer was investigated by placing the animal in different positions during oscillation (standing, lying, suspended with the head up or down).

A Basow gastric fistula was created in the dogs and electrodes were implanted on to the nerve trunks and into the muscular wall of the stomach. It has been shown [2, 3, 5] that the nerve trunks running along the esophagus and spreading out over the lesser curvature are nerves supplying the stomach and the proximal portion of the intestine, so that the electrical activity recorded in these trunks is directly related to the activity of the stomach.

The animals were oscillated in a vertical plane on a stand; the acceleration was varied sinusoidally within the range ±3 g. The animals were placed in a box measuring 700 × 700 × 360 mm, with an illuminating source on the anterior wall. Oscillation was carried out for 20 min 3-4 times per week. The investigation took place 30-40 min

Electrical Activity of Muscular Layer of Stomach of Dogs and Number of Experiments in Which Vomiting was Observed during Action of Linear Acceleration: during Oscillation (a) and during Period of After-Effect (b)

Index	Total number of experiments (32)		Number of tests on animals in certain positions									
			Standing (10 experiments)		Lying (4 experiments)		Lying without flickering of objects (9 experiments)		Lying in the dark (5 experiments)		In a suspended state (4 experiment)	
	a	b	a	b	a	b	a	b	a	b	a	b
Change in electrical activity	17/15	16/16	6/4	9/1	1/3	1/3	4/5	3/6	5/0	4/1	4/0	2/2
No. of experiments in which vomiting was observed	17		9		2		1		2		3	

Note. Numerator—number of experiments with a decrease in electrical activity, denominator—with an increase.

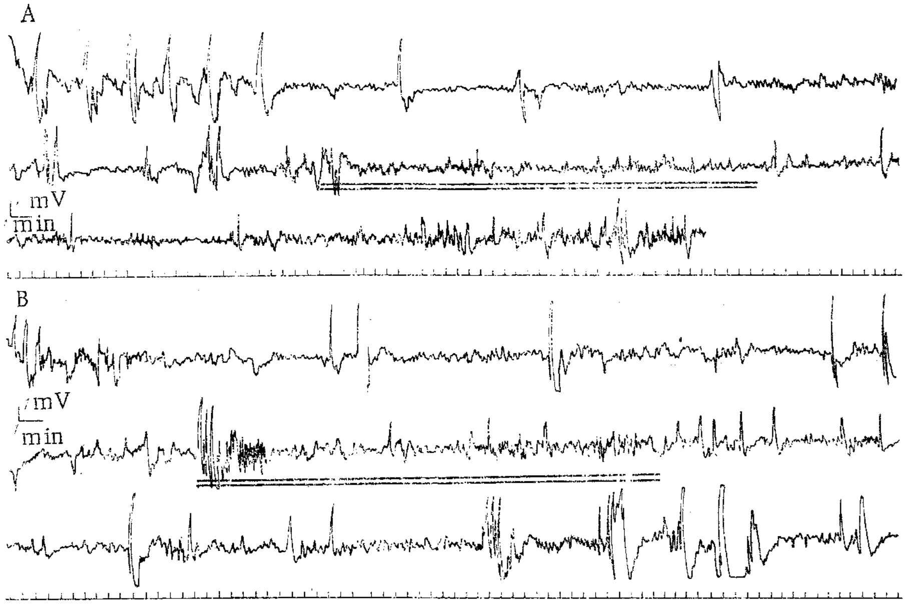

Fig. 1. Electrogastrogram of dog during oscillation in a vertical plane in a standing position (A) and in recumbency (B). Double line—period of oscillation.

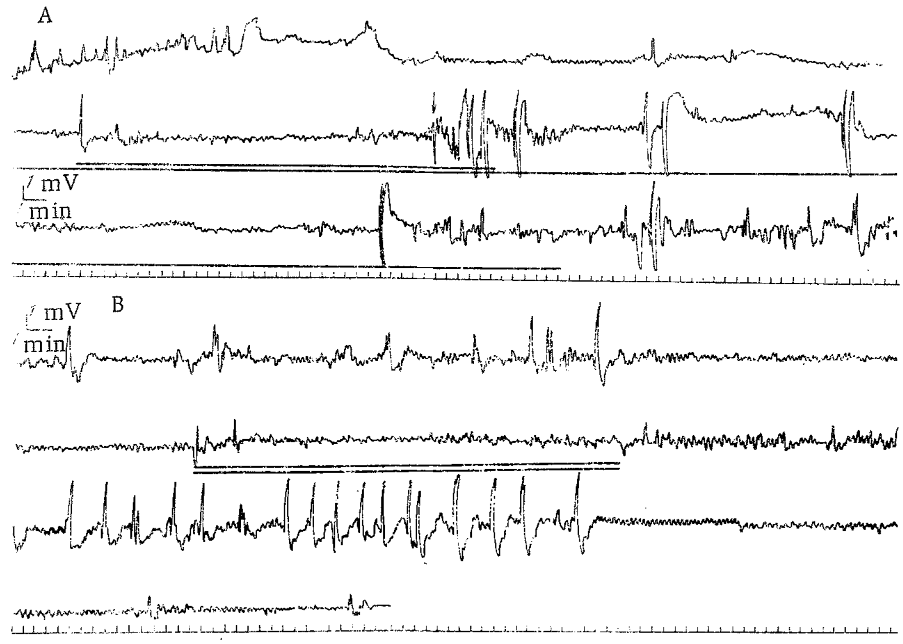

Fig. 2. Electrogastrogram of dog during oscillation in a vertical plane in recumbency in the dark (A) and with exclusion of the proprioceptive function of the eye (with the window of the box covered) (B). Single line—with the box darkened; the arrow indicates the time when vomiting began. Double line—period of oscillation.

before oscillation, during oscillation, and in the course of 1.0-1.5 h thereafter. The electrical activity in the nerve trunks and the muscular layer of the stomach was investigated in 43 experiments on 4 dogs. The action potentials of the nerve trunks were amplified by means of a type UBP-1 amplifier and recorded on a type MPO-2 loop oscillograph, while the potentials of the muscular layer of the stomach were recorded on a type EGS-3 electrogastrograph. In all the experiments consideration was paid to the salivation, the onset of nausea (an increase in the intensity of salivation, the appearance of swallowing movements, licking, restless movements) and vomiting, and the degree of motor restlessness of the animal.

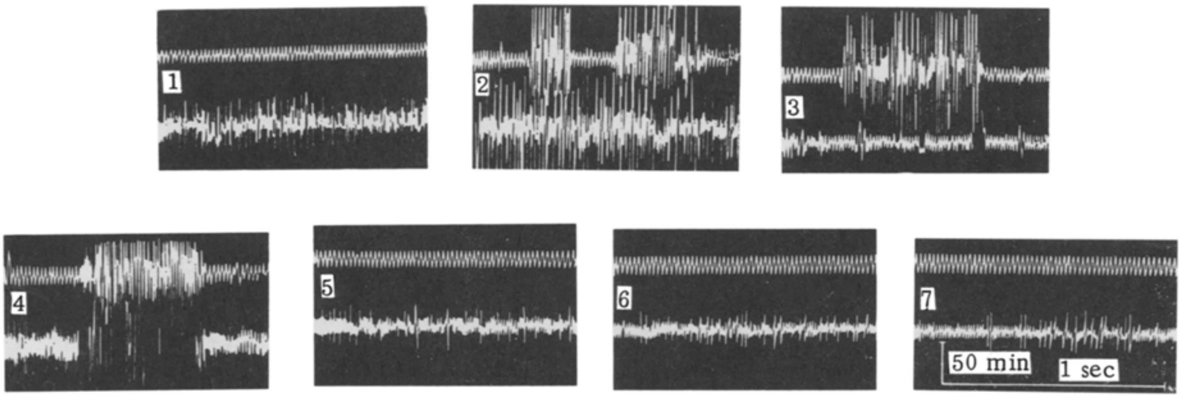

Fig. 3. Change in the electrical activity in the nerve trunks of the dog's stomach during oscillation in a vertical plane. Top curve – activity in nerve of lesser curvature of stomach, bottom curve – activity in nerve of greater curvature. Experiment No. 2 (oscillation in standing position); 1) background; 2) 2nd minute of oscillation; 3) 15th minute; 4) 17th minute, vomiting; 5) 1st minute after stopping; 6) 15th minute; 7) 40th minute.

In accordance with modern ideas, it was accepted that an increase in the intensity of the electrical activity of the muscular layer of the stomach corresponds to the period of its contraction, and a decrease to the depression of the motor activity of the stomach.

RESULTS

As a rule, oscillation in the vertical plane depressed the gastric movements, and this depression lasted for some tens of minutes after the oscillation ceased. It is clear from the table that the most obvious depression of the motor activity took place when the animals were oscillated in the standing and suspended conditions. The depression was much less when the animals were lying (Fig. 1). The animals tolerated oscillation best of all in the lying position and in an illuminated box with the light covered (Fig. 2). In the experiments in which oscillation took place with an uncovered source of light in the box, 5-10 min after the beginning of oscillation the animals themselves adopted a position shielding them from the flickering of objects. This position was usually one in which the animal turned its nose towards the side wall of the box but kept its eyes open. Oscillation in the dark caused a stronger depression of the motor activity. As a rule the motor activity was intensified 15-20 min after oscillation in a suspended condition; when this was changed to a recumbent position the normal motor activity of the stomach was at once restored.

In experiments on anesthetized animals (chloralose, 70 mg/kg), oscillation also caused depression of the gastric movements, most marked when the animals were in the head downward position.

A direct relationship was not always present between the degree of oscillation and the depression of the motor activity. Cases were often observed in which oscillation caused a depression of motor activity, which was revealed clinically by an increase in salivation, the appearance of swallowing movements, licking, and restlessness (the nausea reaction); this state frequently progressed to vomiting. Vomiting always took place against a background of increased electrical activity of the musculayer of the stomach. Unfortunately the EGS-3 apparatus has only one channel and it could not be used to record the trend of the waves of the muscular contractions.

The electrical activity in the nerve trunks of the lesser curvature was irregular (parasympathetic fibers predominate here). As a rule an increase in the electrical activity in the nerves corresponded to an increase in the motor activity of the stomach; the mean amplitude of the impulse was 50 μV (Fig. 3). The electrical activity in the nerves of the greater curvature where sympathetic fibers predominate was relatively constant. Often the impulses followed by the rhythm of the pulse, and their mean amplitude was 50-70 μV. During oscillation, the electrical activity in the nerve trunks increased, and then decreased in intensity, returning to its initial level after a few tens of minutes. During nausea the electrical activity increased in both frequency and amplitude, reaching 100 μV; after the nausea had ceased a period of considerable depression of electrical activity developed. During vomiting the flow of impulses rose sharply, especially in the lesser curvature, and reached 200 μV. During vomiting the impulses took the form of volleys, synchronized on the lesser and greater curvatures. After vomiting a prolonged and considerable depression of electrical activity took place. In the period of the after-effect from time to time a large, but brief, increase in the electrical activity was observed in the nerve trunks, corresponding as a rule to the increase in the electrical activity of the muscular layer of the stomach.

The strongest reaction to oscillation was observed in the first experiments; in the later experiments it was less marked. This was shown by the frequency of the appearance of vomiting, the intensity of salivation, and the degree of motor restlessness of the animal. However, if oscillation was carried out daily, the reaction to oscillation became stronger, so that a pause had to be made in the investigations.

A conditioned-reflex component was clearly seen in the development of motion sickness. The conditioned reflex was formed in response to the experimental conditions and was observed after the first experiment (increased salivation, depression of motor activity of the stomach, excitation of the animal, followed by motor inhibition). In subsequent experiments conditioned-reflex vomiting was repeatedly recorded: no sooner had the dog entered the room in which oscillation took place than it developed motor inhibition, and began to salivate and vomit. Subsequent oscillation caused more severe autonomic disturbances. This compelled us in some cases to carry out the same experiments, but without oscillation. As a rule the next experiments with oscillation were carried out 1-2 days later, when the autonomic disturbances were less severe.

It may be concluded from these investigations that the final effect during oscillation is the result of the complex interaction between analyzers, especially the vestibular, proprioceptive, and optic analyzers. During stimulation of the vestibular apparatus the smallest effect was observed in the case of optimal stimulation of the optic and proprioceptive analyzers, as when the animal was in a normal physiological position in space and optimal stimulation was applied to the optic analyzer (an ordinary light flux and fixation of the eye on an object motionless in relation to the animal).

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