ON THE PROBLEM OF THE FUNCTION OF THE SYMMETRICAL CENTERS

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It is known that, during eating, saliva is secreted from the salivary gland on the side on which the food is being masticated [1,2]. This is especially clear in animals which ordinarily masticate their food for long periods first on one side of the mouth, then on the other (for example, ruminants). If the openings of the salivary ducts are transplanted externally in such animals, salivation can be observed first from one, then from the other salivary gland, according to the side being used for mastication.

In order to obtain the same unilateral salivation in dogs, irritation of the symmetrical portions of the dorsum of the posterior third of the tongue, which has been transplanted externally, can be employed. In this operation, sections of the mucous membrane are transplanted to the skin under the dog's mandible separately from each other (on the right and left). On alternate stimulation of these sections by offensive solutions (acid, salt) or edible substances (bouillon, meat-biscuit powder, etc.), saliva is secreted from the salivary gland on the stimulated side. If some neutral stimulus is combined with the unconditioned reflex action of the salivary gland on one side, a conditioned reflex develops which will be apparent in the form of salivary secretion from the gland on the stimulated side without the unconditioned stimulus. Thus, different positive and negative conditioned reflexes for various stimuli can be developed on the different sides of a single dog.

In studying such unilateral salivary reflexes, naturally the question arose of the path along which the impulse travels from the place where it is formed during stimulation of the receptive surface of one side (in our case, the papillary surface of the tongue) to the place of its overt demonstration in the effective organ (salivary gland) and whether or not this path is different throughout its extent from the path taken by the same stimulation of the contralateral gland.

The solution of this question is of importance in explaining many phenomena observed in the course of investigations of the interrelations of the reflex activity of glands on different sides. In addition, it is difficult, especially since we do not have exact nor complete data regarding the conducting paths in the central nervous system of the dog.

The present work is devoted to the study of the problem of which hemisphere of the brain has the dominant or sole role in determining unconditioned and conditioned reflex salivation from the right and left glands.

In order to solve this problem, experiments were carried out on four dogs. First we established the amount of conditioned and unconditioned secretion from each parotid gland, then we removed the cortex of one hemisphere and determined the resultant change in the salivary secretion of the glands. The conditioned and unconditioned salivary reflexes were studied. The latter were produced singly on each side (by smearing the transplanted section of the tongue) and simultaneously on both sides while eating meat-biscuit powder. Conditioned reflexes were developed on the basis of the corresponding unconditioned ones.

We measured the amount of saliva in millilitres on some dogs, in scalar divisions on others.

TABLE 1

Changes in the Unconditioned Salivary Reflex After Extirpation of One Cerebral Hemisphere

Conditions of the experiment	Salivary secretion from the parotid gland			
	Left	Right	Left	Right
	Dog, "Thunder"		Dog, "Lightning"	
Before operative extirpation of the right hemisphere	5.0	3.7	1100	1020
After operation	5.0	2.2	1100	270
	Dog "Storm"		Dog, "Cloud"	
Before operative extirpation of the left hemisphere	1.7	1.3	3.8	4.6
After operation	1.1	2.2	0.7	3.0

Note: Salivary secretion of the dogs, "Thunder", "Storm", and "Cloud" was measured in millilitres, that of the dog, "Lightning", in scalar divisions.

TABLE 2

Average Magnitude of the Conditioned and Unconditioned Reflexes of the Dog, "Storm", from Data Collected During Five Experimental Days, Before and After Extirpation of the Left Hemisphere*

Conditions of the experiment	Secretion from the parotid gland (in scalar divisions)			
	Left		Right	
	Conditioned reflex	Unconditioned reflex	Conditioned reflex	Unconditioned reflex
Before operation	17	301	14	2227
After operation	0	145	13	2229

*Recording of salivary secretion after operation was begun on the 14th day.

TABLE 3

Change in the Conditioned and Unconditioned Reflexes to Acid on the Left After Extirpation of the Left Hemisphere of the Dog, "Storm"

Time of the experiment	Number of associations	Secretion from the left parotid gland (in scalar divisions)	
		Conditioned reflex	Unconditioned reflex
Experiment on June 24, 1952 (morning of the day of the operation)			
12:42 P.M.	18	10	385
12:47 P.M.	19	15	455
Experiment on July 9, 1952 (on the 15th day after the operation)			
12:15 P.M.	20	0	215
12:20 P.M.	21	0	208

On the day of the experiment, the dog was given 20 g of moistened meat-biscuit powder five times at five minute intervals. The amount of saliva was measured separately from the left and right glands during the same period of time. Above are the reports of the experiments in the form of tables. The numbers appearing on them show the average amount of saliva secreted from the corresponding gland according to data from five days of experimentation; recording of salivary secretion was begun on the third day following the operation.

From the above experiments (Table 1), it is apparent that after extirpation of the cortex of one hemisphere, the magnitude of the unconditioned salivary reflex on the operated side is decreased, while on the "healthy" side these reflexes are not decreased but in some cases, even increased. As a consequence of the decrease in the

magnitude of the unconditioned reflex on the side from which the hemisphere was removed, the relationship between the amounts of salivary secretion from the glands on both sides is sharply changed after the operation and remains thus for a long time (observations on the dog, "Cloud" were continued for 6 months, on "Storm", for 2 years 6 ½ months).

TABLE 4

Magnitude of the Conditioned Reflexes to Acid on the Left and Right Sides of the Dog, "Storm" During Their Establishment After Removal of the Left Hemisphere

Time	Conditioned stimulus	Number of associations	Secretion from the parotid gland (in scalar divisions)	
			Conditioned reflex	Unconditioned reflex
			Left gland (experiment of August 27)	
11:12 A.M.	M_{120}	56	0	215
11:17 A.M.	M_{120}	57	0	180
11:22 A.M.	M_{120}	58	0	180
			Right gland (experiment on August 28)	
11:44 A.M.	Whistle	25	35	400
11:49 A.M.	"	26	80	415
11:54 A.M.	"	27	90	400

During this period, the size of the unconditioned reflex on the side from which the hemisphere had been removed reached the preoperative level in a number of experiments; but at the same time the salivary secretion also increased from the gland located on the side of the remaining hemisphere, so that the relationship which had been established after the operation between the amounts of salivary secretion from both glands did not change.

In the dog, "Storm", the conditioned, as well as the unconditioned reflexes were studied. A conditioned food reflex was developed in it for the sound of a bell in association with eating meat-biscuit powder. The cortex of the left hemisphere of this dog was extirpated after the conditioned reflex had been established; the number of associations of the conditioned stimulus with the unconditioned one reached 60. The results are shown in Table 2.

It is apparent from Table 2 that after extirpation of the cortex of the left hemisphere, the conditioned salivary reflex disappeared and the unconditioned one decreased (145 divisions instead of 301) on the left. On the right, the conditioned reflex did not change, and the unconditioned one even increased slightly.

After the operation, we carried out 400 more associations of sounding a bell with food, and in spite of this, during 5 months the conditioned reflex did not become reestablished on the left side, while the conditioned reflex to the bell appeared constantly on the "healthy" right side.

Earlier, a left-sided conditioned reflex to a metronome with a frequency of 120 beats per minute had been established in the same dog, "Storm". We combined this stimulus with stimulation of the transplanted section of the tongue on the left side by means of an acid solution. The metronome was left on for 20 seconds; it was used twice a day, after the food reflex had been elicited, at intervals of five minutes. The unconditioned stimulation lasted for 20 seconds. Before the operation, a constant conditioned reflex was developed (after 19 associations). We show the results of a typical experiment (Table 3).

After the operation, using the conditioned stimulus (metronome) twice daily and reinforcing it with unconditioned stimulation of the left section of the tongue, we brought the number of associations to 58, but the reflex on the left side did not become reestablished.

Six weeks after the operation we began to work out a right-sided conditioned reflex, combining the sounding of a whistle for 20 seconds with stimulation of the transplanted right section of the tongue with acid for 20 seconds. We used this combination after the food reflexes at intervals of five minutes every other day, alternating it with experiments in which a similar association of conditioned stimulus (metronome) with unconditioned stimulation was used on the left side. The conditioned reflex on the right side was established with the eighth association and was constant. The results of these experiments are shown in Table 4.

On the basis of all the experiments described above, the inference should be made, that, after extirpation of the cortex of one hemisphere, unconditioned reflexes diminish sharply and conditioned reflexes disappear on the side from which the hemisphere was removed, while the reflexes on the "healthy" side do not suffer any sharp changes. Solution of the problem of the duration of the disappearance of the conditioned reflex on the side from which the cortex of the hemisphere was removed remains as a problem for later solution.

LITERATURE CITED

[1] Cl. Bernard, Leçons de physiologie expérimentale appliquée à la medicine, vol. 2, p. 76, Paris (1856).

[2] G. Colin, Traité de physiologie comparée des animaux considérée dans ses rapport avec les sciences naturelles la médicine, la zootechnie et l'écomonie rurale, Paris (1872).