RELATIONSHIP BETWEEN THE PAIRED HEARING CENTERS OF THE DOG'S BRAIN

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We have previously shown experimentally [4] that bilateral extirpation of the auditory cortex (sylvian, ecto-, and suprasylvian gyri) causes a disturbance of fine sound discrimination, whereas sound conditioned reflexes and coarse sound differentiation can be carried out by dogs even in the absence of the nuclei of the auditory zone of the cortex.

Several workers [1, 2, 3, 5, 6] have shown that extirpation of the cortex of one hemisphere in dogs causes the positive sound conditioned reflexes of the salivary gland to disappear on the side of the extirpated hemisphere, but leaves the conditioned reflexes on the opposite side intact. These workers studied only the positive sound reflexes after removal of the cortex of one hemisphere, and were not concerned with conditioned inhibition in these conditions.

We have investigated the effect of unilateral extirpation of various parts and the whole of the auditory cortex on both the positive sound conditioned reflexes and sound discrimination.

EXPERIMENTAL METHOD

Experiments were carried out on 5 dogs in a sound-proof chamber, by the salivary conditioned reflex technique and also in conditions permitting free movement. For the experiments in the sound-proof chamber, the parotid duct on both sides of the dogs was exteriorized by Glinskii's method. A conditioned sound stimulus (tone, bell) was used. Positive sound conditioned reflexes and differentiation between them were formed. All the conditioned stimuli were reinforced by a definite helping of powdered meat and biscuit. The volume of the conditioned and unconditioned secretion of saliva was recorded in scale divisions of a Ganike-Kupalov air-water system separately from the left and right parotid glands.

The experiments in conditions of free movement were carried out in a large room. In response to certain stimuli (tone, bell, light), the dogs were trained to run to different feeding bowls. Bowl No. 1 was situated in front and to the left of the experimental animals and bowl No. 2 in front but to their right. Accordingly, a dog receiving a signal at which reinforcement took place with food from bowl No. 1 tan forward and to the left, but if given a signal at which food was provided from bowl No. 2 it ran forward and to the right. Initially the animals sat in the cage with the doors open. The control panel, behind which the experimenter sat, was hidden from the animal.

EXPERIMENTAL RESULTS

With free movement allowed, the dogs Lokhmach and Dzhek were trained to run to different feeding bowls in response to sound stimuli and to differentiate between sounds. The middle lart of the ectosylvian gyrus was extirpated unilaterally in the dog Lokhmach, while in Dzhek the sylvian, ecto-, and suprasylvian gyri were extirpated unilaterally.

Experiments carried out at different periods after the operation (from 1 to 2 weeks) showed that these operations did not disturb the conditioned-reflex behavioral reactions of the animal.

It may be seen from Table 1 that unilateral extirpation of the auditory cortex did not affect the conditioned running to the different feeding bowls in response to sound stimuli and did not impair sound discrimination (200 and 300 cps). Unilateral extirpation of the middle part of the ectosylvian gyrus (where, according to recent electrophysiological findings, the cortical hearing center of the dog is situated [7]) failed to elicit any disturbance of the

TABLE 1. Results of Experiment No. 1 with Dzhek (8th day after operation)

Time (in min)	Conditioned stimulus and unconditioned reinforcement	No. of combinations (after operation)	Initial position	Latent period	Time taken		Behavior
					to run feeding bowl	after eating to cage	
				in sec			
10	Bell + eating from bowl No. 2	1	Lies in cage, looks towards bowl No. 2	2	6	6	Walks, glancing at bowl No. 2, goes up to it, eats, and walks back to cage
10.3	M 120 + eating from bowl No. 1	1	Lies in cage with head forward	0	4	6	Walks to bowl No. 1, eats, walks back to cage
10.6	Light + eating from bowl No. 1	1	Ditto	0	6	6	Walks to bowl No. 1, eats, walks back to cage
10.9	$Tone_{300}$ + eating from bowl No. 2	2	" "	0	4	6	Runs to bowl No. 2, eats, walks back to cage
10.12	$Tone_{200}$	1	" "				Does not move but lies quietly
10.15	$Tone_{300}$ + eating from bowl No. 2	2	" "				Runs to bowl No. 2, eats, walks back to cage
10.18	$Tone_{200}$	2	" "				Does not move but lies quietly
10.21	$Tone_{300}$ + eating from bowl No. 2	3	" "	0	4	6	Runs to bowl No. 2, eats, walks back to cage

positive sound conditioned reflexes in Lokhmach nor to interfere with sound discrimination (275 and 300 cps).

In other experiments on the dogs Dzhul'bars and Mure, conducted in a sound-proof chamber, food conditioned reflexes were formed in response to sound stimuli and sound differentiation was produced. After the conditioned reflexes had been formed in Dzhul'bars, the ectosylvian gyrus was extirpated on the left side: the operation was not followed by disappearance of the sound conditioned reflexes or by disturbance of differentiation (Table 2). Similar results were obtained with the dog Tut in experiments after unilateral extirpation of the ectro- and suprasylvian gyri.

After the conditioned reflex background had been established in the dog Mura, the cortex of the right hemisphere was extirpated. Experiments carried out after the operation showed that this operation caused disappearance of the salivary reflexes of the gland on the side of the extirpation, whereas all the conditioned reflexes, and differentiation between them, remained intact on the opposite side (Table 3).

Hence, unilateral extirpation of the auditory region of the cortex in dogs causes no changes in the conditioned reflexes or differentiation to sound stimulation, whether free movement is allowed or the experiments are conducted in a sound-proof chamber.

It might be assumed that the auditory cortex plays no part in sound discrimination. However, extirpation of the auditory region of the cortex bilaterally in dogs is followed by a disturbance of fine sound discrimination for a considerable time (1 year). Consequently, after extirpation of the auditory cortex on one side, the symmetrically opposite auditory cortex takes over its function completely.

TABLE 2. Results of Experiment No. 5 with Dzhul'bars

Interval (in min)	Conditioned stimulus*	No. of combinations	Delay (in sec)	Unconditioned stimulus	Left parotid gland		Right parotid gland	
					conditioned reflex	unconditioned reflex	conditioned reflex	unconditioned reflex
Before operation								
5	$Tone_{1000}$	196	15	Eating	90	485	90	485
5	$Tone_{1000}$	197	15	"	72	500	75	545
5	$Tone_{950}$	28	15	–	0	5	0	0
5	$Tone_{1000}$	198	15	Eating	70	480	64	516
5	$Tone_{950}$	29	15	–	8	0	0	0
5	$Tone_{1000}$	199	15	Eating	72	500	65	500
After operation								
5	$Tone_{1000}$	210	15	Eating	60	400	100	415
5	$Tone_{1000}$	211	15	"	80	460	60	460
5	$Tone_{950}$	34	15	–	15	0	8	0
5	$Tone_{1000}$	212	15	Eating	55	410	45	435
5	$Tone_{950}$	35	15	–	0	30	0	30
5	$Tone_{1000}$	213	15	Eating	60	445	60	435

*The numbers used as subscripts denote the number of vibrations per second (cps).

TABLE 3. Results of an Experiment with Mura

Interval (in min)	Conditioned stimulus*	No. of combinations	Delay (in sec)	Unconditioned stimulus	Left parotid gland		Right parotid gland	
					conditioned reflex	unconditioned reflex	conditioned reflex	unconditioned reflex
Before operation								
5	$Tone_{1000}$	137	15	Eating	45	448	45	440
5	$Tone_{1000}$	138	15	"	30	450	32	415
5	$Tone_{1000}$	139	15	"	50	450	48	436
5	$Tone_{950}$	42	15	–	5	45	0	38
5	$Tone_{1000}$	140	15	Eating	50	516	46	445
After operation								
5	$Tone_{1000}$	158	15	Eating	34	600	0	296
5	$Tone_{1000}$	159	15	"	38	614	5	295
5	$Tone_{950}$	48	15	–	8	95	0	0
5	$Tone_{1000}$	160	15	Eating	50	616	0	285
5	$Tone_{950}$	49	15	–	5	55	0	0
5	$Tone_{1000}$	161	15	Eating	50	580	0	294

*The numbers used as subscripts denote the number of vibrations per second (cps).

After extirpation of the cortex of one hemisphere, sound conditioned reflexes disappear on the ipsilateral side but remain intact on the contralateral side. It is interesting, however, that sound discrimination too is preserved in the gland on the side of extirpation.

SUMMARY

It may be concluded from these experiments that after unilateral extirpation of various parts or the whole of the auditory cortex and after total removal of the cortex of one hemisphere, there is no disturbance of conditioned excitation and conditioned inhibition in the symmetrically opposite region of the cortex. The results also demonstrate that the presence of the cortical auditory center of either hemisphere is sufficient to ensure find sound discrimination in dogs.

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