DAMAGE TO THE FRONTAL AND PARIETAL LOBES OF THE BRAIN AND CONDITIONED REFLEXES IN UNCONSTRAINED SUBJECTS

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 55, No. 4,
pp. 22-25, April, 1963
Original article submitted February 12, 1962

At present we need to know how to localize function in the cortex not only in connection with physiological requirements but also in pathology, particularly in connection with clinical observations on patients with damage to various portions of the cerebral cortex. Also, a study of the after-effects of damage to the different regions is interesting in connection with compensatory adaptations [1, 3].

In damage to the frontal lobes typically movement is impaired, and we have therefore used a method in which movements were noticeably affected.

EXPERIMENTAL METHOD

The experiments were carried out on three dogs in which conditioned reflexes were elaborated by Kupalov's method while the animals were unconstrained; the principle of the method is gradually to increase the complication of the behavior by the introduction of new stimuli.

In all the dogs the stimulus used was a metronome striking at 120 beats/min. After reinforcement of the conditioned reflex to this stimulus, quite independently of where the animal was in the room, it approached the feeding trough and obtained food.

After reinforcement of the positive conditioned reflex to the sound of the metronome at 120 beats/min we altered the conditions of the experiment: the positive stimulus was given only if the dog was on a mat placed 3 m from the feeding trough. After several combined stimuli the behavior of the dog became related to the particular position on the mat. In between the stimuli the dog stood on the mat. If the metronome was sounded at a different frequency of 60 beats/min the dog remained on the mat. When we had elaborated this complex form of behavior we then extirpated the cortex of the frontal and parietal lobes, in order to reveal behavior disturbances. Recovery occurred 5-7 days after the operation.

EXPERIMENTAL RESULTS

A conditioned motor reflex to the positive sound stimulation in the dog Chita was developed by 11-12 combined presentations of stimuli.

On the 4th day we used an inhibitory stimulus, and found indications of differentiation: when the differential stimulus was applied the dog made three or four steps, stopped, and then returned to the mat. Distinct differentiation was developed after 20-23 applications of the inhibitory stimulus, after which it was maintained.

When this form of behavior had been elaborated we removed the frontal lobe. We removed fields 4 and 6 of the map of Gurevich and Bykhovskaya.

On the 5th day after the operation the animal was tested. When the conditioned stimulus was applied it remained still and ran to the feeding trough only at the sight and sound of the trough with food when it was offered. However, even by the next day, when the metronome was sounded at 120 beats/min, Chita ran to the food. The inhibitory stimulus also caused a motor response directed towards the feeding trough. In the intervals between the stimulus the dog

Experiment on Dog Chita

Time of application of conditioned stimulus	Sequential number of combined applications	Conditioned stimulus	Isolated action (in sec)	Latent period (in sec)	Feeding	Motor response
13 hr, 40 min	339	Metronome 120	15	1	+	Ran to feeding trough; after feeding attempted to overturn the next cupful of food, then moved all over the room, once more approached feeding trough and again attempted to overturn the cup. Sat down near the mat.
13 hr, 42 min	340	Metronome 120	15	1	+	After feeding stood up between the mat and the door, and after 30 sec, sat on the mat.
13 hr, 45 min	94	Metronome 60	15	2	–	After 2 sec, it rose from the mat and approached the feeding trough; at the 6th sec, it sat on the mat and after 35 sec, it began to move about the room, and then again sat on the mat.
13 hr, 47 min	341	Metronome 120	15	1	+	After feeding it moved around the room, and after 40 sec, sat on the mat.
13 hr, 49 min	342	Metronome 120	15	1	+	Ran to the feeding trough, ate the food, ran towards the door, again approached the feeding trough, tried to overturn the cup and sat on the mat.
13 hr, 51 min	95	Metronome 60	15	1	–	Ran to the feeding trough and while the metronome sounded, it stood by the trough, whimpered, and then sat on the mat.
13 hr, 53 min	343	Metronome 120	15	1	+	After eating, sat on the mat.

sometimes approached the feeding trough (see Table). After the operation, for some 8-10 days signs of motor excitation appeared. Before the experiment the dog ran about for 3-4 min continuously in the room, and not until afterwards did it settle at the trough. In between applications of the stimuli, particularly for the first 6-8 days after the operation, the dog ran backwards and forwards to and from the trough. Subsequently these changes abated. The conditioned reflex to the trough was strengthened. Thus even by the 7-8th day, in the intervals between the applications of the conditioned stimuli the dog was almost always to be found on the mat.

Therefore, after damage to the frontal lobes in Chita the positive motor conditioned reflex was maintained, but differentiation failed for the following 2-2½ weeks. Also, for the first 7-8 days after the operation, the animal was more active and engaged in aimless movements about the room in between the application of the conditioned stimuli.

In the dog Mal'va we also elaborated the same motor responses as in Chita and then extirpated the parietal lobes of both sides (removing field 7 of the map of Gurevich and Bykhovskaya).

On the 3rd day after the operation, when the positive conditioned stimulus was applied Mal'va stood motionless, but approached the feeding trough in response to the sound of the food trough being rotated. The effect of the inhibitory stimulus was to cause the dog to run towards the feeding trough. The conditioned reflex to the sound of the metronome disappeared for a short time in 3-4 experiments. After recovery of the conditioned reflex the latent period of response was increased from 1 to 3-4 sec. The inhibitory stimulus induced a positive motor response directed towards

the food, and in the intervals between the stimuli the dog several times approached the feeding trough and attempted to open it. Stable differentiation returned after 11-12 days. It should be noted that in Mal'va we observed no motor excitation such as we had seen in Chita after damage to the frontal lobes.

In the dog Volchikha we also damaged the parietal lobes. The results of the experiments with this dog were similar to those found for Mal'va.

After damage to the frontal lobes thd dog suffered from ataxia, there were signs of motor excitation, and chewing was impaired. These symptoms were not found after damage to the parietal lobes. The effects lasted for 8-10 days after the operation, and gradually abated. By the 22-25th day the previously elaborated conditioned reflexes returned complete with differentiation.

After damage to the parietal lobes the recovery of the conditioned reflex did not differ over-all from what was found in dogs with damaged frontal lobes. However we never recorded from them the characteristic changes which developed after frontal lobe damage.

Some investigators [6, 7] have attributed this effect to the absence of an inhibitory influence exerted by the frontal lobes on the lower-lying regions of the central nervous system, so as to cause an enhanced motor activity. Others [5, 8, 9] maintain that the frontal lobes are a coordinating center for sensory information and motor acts, and their destruction leads to corresponding changes. P. K. Anokhin [2] attributes enhanced motor activity in dogs with extirpated frontal lobes to the presence in the central nervous system of two excitatory systems corresponding to the two aspects of reinforcement of the conditioned stimulus. N. A. Shustin [4] thinks that impairment of reflex activity after bilateral extirpation of the frontal lobes is due to damage of the cortical connections between the thalamus and hypothalamus.

From our observations it would appear that the motor activity might be due to considerable damage to the motor analyzer in the frontal lobes at the operation. During the first 2-3 days after the operation the dogs moved very little and scarcely reacted to the approach of the experimenter. This behavior was the result of postoperational inhibition. As the cortex recovered from this postoperational condition excitation preponderated over inhibition. This was especially true in the other parts of the motor analyzer, a fact which explains the increased motor activity.

Subsequently, as a result of recovery of the balance between excitation and inhibition, and also because of the compensatory adaptation of the cortex this enhanced motor activity gradually disappeared. Because in the operation to the parietal lobes the operation did not affect the motor analyzer, no such behavior was observed in these animals.

SUMMARY

Higher nervous activity and motor disturbances were studied in three unconstrained dogs before and after injury to the frontal or parietal lobes. There was no difference in the recovery time of conditioned reflex activity as between dogs with frontal or parietal lobe injury. However, damage to the frontal lobes led to motor disturbances and prolonged motor excitation, and the animals moved about aimlessly. These effects were observed both in the laboratory and in the animal house.

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