THE BEHAVIOR OF CATS FOLLOWING BILATERAL REMOVAL OF THE ROSTRAL PORTION OF THE CEREBRAL HEMISPHERES*

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Two recent studies of the effects of bilateral removal of the frontal lobes of the cerebral cortex of the cat have been at considerable variance as to the symptoms obtained. Langworthy and Kolb ('35) have observed an exaggeration in motor activity in their animals and make no mention of a pronounced plasticity in the decorticate extensor hypertonus. Barris ('37), on the other hand, has reported a profound loss of motor initiative together with a hypertonus of an extremely plastic type suggestive of catalepsy and his comparison of this cataleptic condition with that investigated in this laboratory after brain stem lesions has led us to attempt to verify his observations. We have, therefore, subjected a series of cats to bilateral one stage removal of the frontal lobes.

Methods

The animals were operated under nembutal in the manner employed by Barris ('37). The skin was incised, the frontal sinuses opened, the nasofrontal ducts plugged with bone wax and the interior of the sinuses sponged with merthiolate. The anterior portion of the calvarium was then removed, the dura incised and all large available vessels were tied and sectioned. The cerebral hemispheres anterior to a plane in the region of the ansate sulci were removed on each side, hemorrhage was stopped, the subcutaneous tissue sutured and the skin closed with clips. Three animals were so active on the first and second postoperative days that they knocked the clips out of the anterior part of the medial longitudinal incision. These animals were kept in a large cage during the first few postoperative days. Intraperitoneal injections of normal saline solution were administered daily until the animals ate.

The survival times of these eight animals were as follows: One cat suddenly became prostrate and died on the sixth postoperative day, possibly from embolism. One animal, in good health, widely opened its skin incision as a result of excessive activity during confinement for a test of temperature regulation on the sixth postoperative day, and was killed. Four to six weeks after operation, the remaining six animals were utilized in terminal experiments in which the excitability of the preoptic region and hypothalamus was tested. The results of the latter study, together with the information obtained regarding temperature regulation in these animals, will be reported in con-

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connection with other work. The following description is concerned with the animals' general symptomology.

Results

Activity, postural defects, tonus. In light of the loss of motor initiative which has been claimed for them, these animals exhibited a remarkable amount of activity usually from the first or second postoperative day onward. This was perhaps not abnormal since we have seen very restless normal cats which have been just as active. The activity was usually confined to an almost continuous walking about, but two of the animals trotted across the room on the third and fourth postoperative days. Though in motion most of the time when out of their cages for observation, the animals often stopped to look at other cats and seemed perfectly capable of inhibiting their activity. They would not at first turn aside to avoid obstacles, however, and with considerable difficulty would scramble over the rungs of a low stool in their path, or when walking across a table would walk over the edge. They showed a pronounced disposition to follow the observer duplicating every turn made by him.

At a time varying between the first and second postoperative week two of the animals lost this over-activity and disposition to follow and became about as quiet as the average laboratory cat. It was found at autopsy that these two animals suffered smaller cortical ablations than their fellows who continued to exhibit the above tendencies throughout their survival periods.

The loss of postural reactions, which the exacting study of Bard ('33) has shown to be dependent on the sensori-motor region involved in these ablations, made the animal's progress awkward during the first postoperative days, but improvement was rapid and subsequently postural defects were chiefly apparent when an animal was at rest, or starting or stopping motion, or when making a turn. These defects were usually manifest as a slipping of one or more of the limbs from under the body, forward, to the side or backward, or as a stepping on the dorsum of the foot. In two instances the fore limbs were crossed. Running or scrambling movements appeared when the animals were restrained from moving forward, the animals often becoming very excited.

It was quite impossible to pose the animals in any position.

An extensor hypertonus of the limbs was apparent in the standing posture and gait of two animals on the first postoperative day; but was usually present only when the limbs were freed of participation in standing or walking. It was seen best when the animal was suspended ventral side down either by the chin and tail or in a hammock, and then was marked and exhibited no plasticity. Usually in the course of the first postoperative week the animals became restless in the hammock, swaying the vertebral axis from side to side and making running movements of small amplitude. In most cases an extensor hypertonus of the limbs was apparent also when the animals were on their backs in a trough during the first two or three postoperative days, and some
of the animals would lie quietly in this position during the first postoperative week. Others, however, had to be restrained in the trough from the first postoperative day and righted themselves as soon as released, at first by a ventroflexion of the trunk and later by turning to the side. There was little or no plasticity in the extensor hypertonus in any of the animals when on their backs and it was impossible to pose any of them in the trough.

**Feeding, gastro-intestinal tract.** With the exception of one cat which ate meat on the first postoperative day and drank milk on the second, the animals would not eat meat spontaneously until the fourth to sixth postoperative day and would not drink milk until the sixth to eighth day. All would chew and swallow meat placed in their mouths two or three days before they began to eat spontaneously. In eating meat some of the animals licked the meat into their mouths, while others made lunging bites and swallowed the mouthful obtained without chewing. They would indiscriminately bite or lick the edges of the pan. All of the animals lapped milk, often lapping the edge of the pan or the air, or dipping the nose far into the milk. When feeding, the animals frequently made treading or pawing movements with the forelimbs, placed the forefeet in the dish, and sometimes purred or growled. They appeared very hungry.

The same two cats which lost their over-activity and disposition to follow quickly acquired better eating habits than their fellows. The animal which ate from the first postoperative day was not a member of this group, however.

The stomach and intestines of each animal were examined at autopsy, but the results do not compare favorably with those of Mettler, Spindler, Mettler and Combs ('36) who found gastric hyperemia and ulceration following bilateral removal of the frontal lobes in the cat. A single ulcer was found in the pyloric region of the stomach of the animal which died on the sixth postoperative day. This consisted of an area of mucosal erosion about 2 mm. in diameter with slightly elevated and pinkish margins. We question its relationship to removal of the frontal lobes, however, for the stomach and intestines of all the other animals were normal.

**Emotional behavior.** We cannot agree with Barris ('37) that there is any more than a very transient impairment in the emotional reactivity of these animals. The response to pinching the tail was uniformly weaker than normal during the first, second and third postoperative days. It regained a normal vigor during the fourth to sixth days, however, and on pinching the tail the animals cried loudly, spat, circled and in some instances attempted to strike the observer's hand.

Three of the cats exhibited an aversion to their fellows from the third postoperative day onward. One of these animals, when another cat approached her on the third postoperative day, rolled onto her side, extended the limbs in front of the fore part of the body, with the digits spread and claws bared, and repeatedly struck with the uppermost forelimb; the ears were retracted, the pupils widely dilated, the cat spit several times and for a short time afterward growled intermittently.
The animals showed every indication of marked emotion when in a room with barking dogs in cages, but unfortunately this was not tried until most of the animals were in their first or second week of survival, and the earliest test was on the sixth postoperative day. In this instance the cat faced the dog which was barking the loudest and remained in the center of the room, with its limbs extended, back arched, and tail vertically upright. The hair on the back and tail was maximally erected and the pupils maximally dilated. The cat's repeated, explosive spitting could be heard above the noise of the dogs. The cats with longer survival times exhibited just as normally vigorous pilomotor, pupillary and facio-vocal activity but instead of assuming the Halloween posture just described, crouched and retracted the forequarters.
and head, and two of the animals subsequently turned and ran out of the room.

With the possible exception, however, of the three cases which were antagonistic toward their fellows, a trait occasionally present in the normal cat, these animals have not impressed us as possessing the intense emotional hyper-excitability seen in the completely decorticate cat (Bard, '28; Bard and Rioch, '37).

The animals showed a pronounced affection toward the observer. They circled, arched and rubbed themselves against the observer when petted, often purring and making treading movements with the forelimbs, and when studying the animals it was difficult to take notes with the cats on the table as they would not stay away from the observer.

Extent of ablation. In all of the animals the posterior sigmoid, anterior sigmoid and most of the coronal and frontal gyri (terminology after Papez, '29) were removed bilaterally. In the two animals which recovered from an initial over-activity and tendency to follow, and which regained essentially normal eating habits, this was the extent of the area ablated, as is seen in the photograph of the brain of Cat 1, shown in Fig. 1B. The extent of ablation can be determined by a comparison with the normal brain shown in Fig. 1A.

In the remaining four animals the ablation was slightly more extensive so that the anterior ends of the lateral, middle suprasylvian and anterior ectosylvian gyri were removed and all of the coronal gyri and the anterior half to two-thirds of the anterior sylvian gyri were bilaterally ablated. Even the most ventral portions of the frontal gyri were either removed or disconnected from more caudal regions. In three of these animals the olfactory tracts were considerably injured on one or both sides, as in Cat 3, whose brain is shown in Fig. 1D, but in one animal, Cat 2, whose brain is shown in Fig. 1C, they appeared intact and it was this cat which ate from the first postoperative day. All four of these animals, however, showed persistent impairments in feeding habits, a deficit which has been attributed by Langworthy and Kolb ('35) to removal of the electrically excitable cortical field for masticatory and lapping movements located in the region of the rostral end of the anterior sylvian gyrus (Magoun, Ranson and Fisher, '33; Ward and Clark, '35; Tower, '36). The present results, as far as they go, support this interpretation, but isolated removal of this field might be expected to yield more critical information.

**Summary**

A description is given of the pronounced activity, loss of postural reactions, extensor hypertonus without plasticity, impairment in feeding and retained emotional behavior of cats following bilateral one stage removal of the frontal lobes of the cerebral cortex.

This description appears essentially identical with that presented by Langworthy and Kolb ('35). The cataleptic phenomena described by Barris ('37) were not observed.
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