Caudate nucleus lesions and maternal behavior in the rat¹

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Six rats received lesions involving the head of the caudate nucleus, the corpus callosum and the deeper layers of the frontal neocortex, and seven rats served as sham operated controls. Postoperatively the animals were mated and their behavior was observed for the first six days postpartum. Although the experimental Ss were more active, they showed no impairment in maternal behavior.

In submammalian species, deficits in parental behavior have been reported to result from destruction of forebrain structures comparable to the mammalian corpus striatum and frontal cortex (Rogers, 1922; Noble, 1936; Jung & Hassler, 1960; Segaar & Nieuwenhuys, 1963). The interpretation of these findings is complicated by the fact that the lesions involved the archistriatum, a structure functionally related to the limbic system, rather than the basal ganglia (Crosby et al, 1962). The present study was undertaken to expand investigations of the role of the striatum in parental behavior. Specifically, the aim was to investigate maternal behavior in the rat with bilateral caudate nucleus lesions.

Subjects

The Ss were 13 female Sprague-Dawley albino rats. Six rats underwent two-stage bilateral electrolytic lesioning of the head of the caudate nucleus. The surgical technique has been described previously (Kirkby & Kimble, 1967). Lesions were made by passing a 2.0 mA current for 25 sec through an electrode stereotactically aimed at points 2.1 mm anterior to Bregma, 2.3 mm lateral to the midline, 3.5 and 4.3 mm below the surface of the skull. Seven rats served as controls. These Ss were anesthetized, placed in the stereotaxic instrument, and an incision made along the dorsal surface of the scalp. The lesions were sutured and the animals removed from the stereotaxic instrument and allowed to recover.

At the completion of the experiment, the experimental Ss were sacrificed, the brains removed, frozen, sectioned at 25 m μ , and stained with cresyl violet and thionine. Histological examination showed destruction of 25% to 70% of caudate tissue. In all cases the lesion penetrated the corpus callosum and involved the deepest layers of frontal neocortex. The area of the lesions is shown in Fig. 1.

Apparatus

The observation cage was a wooden box 38 cm long x 16.5 cm wide x 15 cm deep. A 15 x 10 cm platform was constructed in one corner of the box, 6 cm above the floor. Food was contained in an open feeder 8 x 4 x 3 cm placed midway along the side wall, 8 cm

above the floor. A water bottle was fixed externally at the end of the box so that the metal spout protruded 1 cm into the apparatus, 9 cm above the floor. Pilot investigations showed that an adult rat could reach food and water without leaving the platform. The floor of the box was covered with Sanicel to a depth of 2.5 cm. The apparatus was roofed with a 1.5 cm wire mesh lid.

Four observation cages were mounted on a bench in the experimental room in front of a one-way glass screen, enabling the E to observe the behavior of the Ss from the adjoining room.

Procedure

Fourteen to 21 days after surgery the S was placed in a mating cage with a sexually experienced male rat of tested virility. Invariably, the S appeared pregnant within 10 to 32 days. Forty-eight hours before the estimated time of parturition, the S was placed in the observation box. The box was checked through the one-way mirror three times daily—10 AM, 4:30 PM, and 11 PM. Immediately it was observed that the S had given birth, the E entered the room and, wearing surgical gloves, counted and weighed the litter. At this time 15 strips (approximately 10 x 1 cm) of absorbent paper were placed on top of the platform to provide nest-building material, additional to the Sanicel.

The maternal behavior of the Ss was sampled by means of a check list method similar to that used by Kimble et al (1967). Observations were made at 10 AM, 4:30 PM, and 11 PM for the first six days postpartum, a total of 18 observation periods. Each observation period lasted 10 min. In this time, 60 observations, one every 10 sec, were recorded by

Fig. 1. Area of the caudate nucleus lesions (at approximately 8.6 mm Anterior.)

the E. The observations were recorded by means of a check list containing 10 classifications of behavior decided upon by pilot studies (Table 1). Additionally, as the pilot work had suggested that the operated Ss tended to be hyperactive, a record was kept of the amount of time each S spent in gross activity. This classification included time spent in locomotion, grooming self or pups, retrieving or manipulating pups, and exploring the cage. All scoring was done blind.

Results

The time spent by each rat on each behavior was calculated as a percentage of the total time the animal was observed (Table 1). The scores of both groups were compared using a Mann-Whitney U test (Siegel, 1956). This analysis indicated that the striatal animals spent significantly more time than the controls in "activity" behavior ($p < .044$, two-tailed) and in grooming or manipulating pups ($p < .034$, two-tailed). The litter size, average weight at birth, and survival rate for animals of both groups were calculated and tested for differences (Table 2).

Discussion

The findings indicated that the maternal behavior of the rat is not impaired following lesion to the striatum and deeper layers of the neocortex of the frontal lobes. Damage to the caudate nucleus has been reported to disrupt metabolic processes (Heath et al, 1947; Whittier & Orr, 1962). In the present investigation, any alterations in metabolic processes which might have occurred were not reflected by differences between sizes, birth weights, or survival rates of litters from operated and unoperated mothers.

Although no qualitative measures were taken of mating behavior, it was observed that all striatal

Table 2. Mean litter size, birth weight and survival rate.

	Striatal	Unoperated	U	P (two-tailed)
Litter size	11.17	13.00	10.5	.158
Birth weight (gm)	13.90	15.22	19.5	.890
Survival rate (%)	72.56	67.62	21	1.000

rats had successfully mated within 32 days. This observation is not in accord with the report that ablation of the striatum resulted in chronic impairments in the mating ability of the cat (Wang & Akert, 1962). However, this report must be viewed with caution, for not only were the findings based predominantly upon observations of a single experimental S, but examination of the lesion of this cat revealed extensive involvement of rhinencephalic, neocortical, pallidal, and thalamic areas.

The finding that striatal animals spent more time in "activity" behavior, and in grooming and manipulating pups, is consistent with reports of hyperactivity in caudectomized rats (Whittier & Orr, 1962).

References

- CROSBY, E. C., HUMPHREY, T., & LAUER, E. W. Correlative anatomy of the nervous system. New York: MacMillan, 1962.
- HEATH, R. G., FREEDMAN, D. A., & METTLER, F. A. Striatal removal without previous cortical ablation: release, disorientation, metabolic disturbance. *Fed. Proc.*, 1947, 6, 126.
- JUNG, R., & HASSLER, R. The extrapyramidal motor system. In J. Field, H. W. Magoun, and V. E. Hall, (Eds.), *Handbook of physiology*, Vol. 2, Amer. Physiol. Soc.: Washington, D. C., 1960, Pp. 863-927.
- KIMBLE, D. P., ROGERS, L., & HENDRICKSON, C. W. Hippocampal lesions disrupt maternal, not sexual behavior in the albino rat. *J. comp. physiol. Psychol.*, 1967, 63, 401-407.
- KIRKBY, R. J., & KIMBLE, D. P. Avoidance and escape behavior following striatal lesions in the rat. *Exp. Neurol.*, 1967, in press.
- NOBLE, G. K. The function of the corpus striatum in the social behavior of fishes. *Anat. Rec.*, 1936, 64, Supp. 3, 34.
- ROGERS, F. T. Studies of the brain stem. VI. An experimental study of the corpus striatum of the pigeon as related to various instinctive types of behavior. *J. comp. Neurol.*, 1922, 35, 21-59.
- SEGAAR, J., & NIEUWENHUY, R. New etho-physiological experiments with male *Gasterosteus aculeatus*, with anatomical comment. *Anim. Behav.*, 1963, 11, 331-344.
- SIEGEL, S. *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill, 1956.
- WHITTIER, J. R., & ORR, A. Hyperkinesia and other physiologic effects of caudate deficit in the adult albino rat. *Neurology*, 1962, 12, 529-539.
- WANG, G. H., & AKERT, K. Behavior and reflexes of chronic striatal cats. *Arch. Ital. Biol.*, 1962, 100, 48-85.

Notes

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Table 1. Time spent on each behavior as a percentage of the total observation time.

	Striatal	Unoperated	U	P (two-tailed)
Nursing	41.79	39.23	21	1.000
Sleeping	19.15	21.55	16	.534
Sitting or lying on platform	13.76	24.64	16	.534
Grooming, or manipulating pups	9.73	1.87	6	.034*
Grooming self	4.78	3.29	18	.730
Eating	4.17	3.59	20	.946
Exploring cage	2.60	1.58	13.5	.330
Drinking	1.27	1.60	15.5	.490
Nestbuilding, or retrieving pups	1.44	0.91	18	.730
Other behaviors	1.38	1.94	19	.836
Activity behavior	17.72	7.65	6.5	.044*

* Significant ($P < .05$)