Impairment of one-way active avoidance in rats with habenular or dorsomedial thalamic lesions*

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This study examined the effect of habenular or dorsomedial thalamic lesions on one-way active avoidance behavior in the rat. It was found that habenular lesions impaired avoidance responding and that the deficit appeared to be related to an abnormal freezing tendency. Dorsomedial thalamic lesions also resulted in impaired avoidance responding. However, since the thalamic lesion included several nuclei, it is not clear if any one nucleus was responsible for the effect.

Habenular damage leads to a variety of behavioral abnormalities. For example, rats with habenular lesions are deficient in passive avoidance performance but superior to normal animals in two-way active avoidance (Van Hoesen, MacDougall, & Mitchell, 1969); they extinguish a postoperatively learned CER more rapidly than normal (Brady & Nauta, 1955); they are hyperactive in a brightly illuminated open field and are deficient in one-way active avoidance (Nielson & McIver, 1966). However, this last task was somewhat complex and, consequently, difficult to compare to other one-way active avoidance findings. The animals were required to run to one arm of a T-maze and press a lever in order to avoid shock. In addition, the correct arm was always opposite the arm initially chosen on the first trial. Thus, although the findings in passive and two-way active avoidance are comparable to those seen as a consequence of hippocampal or septal lesions (Kimble, Kirkby, & Stein, 1966; McCleary, 1966; Olton & Isaacson, 1968), it is not clear whether habenular lesions would also lead to deficits in a simpler one-way active avoidance task, where the animal has to run a straight path from one compartment to another. Such deficits have been found in animals with septal (Kenyon & Kriekhaus, 1965; Vanderwolf, 1964), hippocampal (Olton & Isaacson, 1968), and dorsomedial thalamic lesions (Vanderwolf, 1962, 1963; Olton & Isaacson, 1967).

The aim of the present experiment was to extend previous findings on the effects of habenular lesions on one-way active avoidance. These

findings were compared with those of animals with lesions of the underlying dorsomedial thalamus, as well as with operated controls.

SUBJECTS AND PROCEDURE

The Ss were male albino rats, approximately 70 days of age at the time of surgery. They were individually housed in wire cages and were handled for 7 days prior to surgery. A 12-h light-dark cycle was maintained throughout the study. All testing was done during the dark part of this cycle.

Surgery was performed in one stage. The animals were given atropine sulfate to suppress mucous secretion. Ten minutes later, they were anesthetized with Nembutal (52 mg/kg). The animals were then placed in a stereotaxic apparatus and given radio-frequency lesions of the habenula (N = 21) or dorsomedial thalamus (N = 20). Surgical controls were treated the same as experimental animals, except that the electrode was not lowered. Following brain surgery, the animals were sutured and given a broad-spectrum antibiotic.

The avoidance apparatus was a 30 x 6½ in. wooden box with 19-in.-high walls. The box was divided in half by a guillotine-type sliding door and had a Plexiglas window in one wall. The grid floor in the left compartment was connected to a Grason-Stadler shock generator. A 10-W frosted light in the right-hand compartment, which was turned on when the sliding door was opened, and the opening of the door served as the CS. The UCS consisted of 0.5-sec pulses of 0.8-mA footshock.

Training commenced 21-23 days postoperatively when the animal was given 10 min to explore the apparatus. On the following day, the animal was placed in the left-hand compartment, facing away from the door. Twenty seconds later, the door was opened and the animal was allowed 10 sec in which to run into the safe right-hand compartment. If the rat failed to avoid

in the 10-sec interval, shock was administered until it escaped. As soon as the rat moved into the safe side, the door was closed and the CS terminated. The animal was kept in the safe side for 35-40 sec, then transferred by hand into the left side. Each rat was given 20 trials per day for 3 days.

RESULTS

Histology

Histological analysis was done without knowledge of behavioral scores by comparison of thionin-stained brain sections with the atlas of König & Klippel (1963). Animals whose brains showed damage in the dorsomedial region of the thalamus in addition to habenular damage were not included in the statistical analysis. Six of the 21 animals in the habenular group (Habs) had lesions with no discernable damage in the dorsomedial thalamus. The lesions of the thalamic group were quite variable and included several nuclei. However, it was possible to visualize two distinct subgroups: one with damage confined mainly to the dorsomedial, posteromedian, and parafascicular nuclei (DM) (N = 8), and a second group with larger lesions, including the above-mentioned structures plus parts of the lateral, ventral, and posterior thalamic nuclei, bed nucleus of the posterior commissure, periventricular nuclei, dorsal longitudinal fasciculus, and fasciculus retroflexus (Thal) (N = 6). Figure 1 shows diagrams of representative brains. The diagrams represent the brain section exhibiting maximum cross-sectional damage for the animal.

Avoidance

Table 1 shows the mean and range avoidance scores. Pairwise comparisons were made with two-tailed Mann-Whitney U tests in conjunction with Ryan's (1960) correction for multiple comparisons. All comparisons were made at the .05 level of significance. These comparisons showed that the Habs made significantly fewer avoidances than the operated controls. The Thals also made significantly fewer avoidances than the operated control group. Although the DMs made fewer avoidances than the operated controls, this difference was not significant. Comparisons among the lesioned groups showed that both the Thals and the Habs made significantly fewer avoidances than the DMs. However, there was no significant difference between the Thals and the Habs.

Escape and avoidance latencies were also gotten for each trial. The mean escape latencies were 11.4, 11.0, 11.3, and 11.3 sec for the operated controls, Habs, DMs, and Thals, respectively.

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Fig. 1. Representative lesions from each group. Upper diagram shows a representative lesion from the habenular and DM groups. Lower diagram is representative of the Thal group. Diagrams are from König & Klippel (1963).

The avoidance latencies for these groups were 3.1, 4.6, 2.0, and 4.4 sec. There were no significant latency differences for any comparison.

DISCUSSION

The fact that animals with habenular lesions were deficient at avoidance responding corroborates the earlier finding of Nielson & McIver (1966). These authors do not mention the animals' response latencies or whether the responses occurred prior to the onset of shock. However, they do note that the animals had difficulty overcoming their initially incorrect position response. It is possible, then, that the deficit was due to a strong perseverative tendency, as has been postulated to account for the deficit seen in septal animals tested in the same situation (McCleary, 1966). However, if the deficit were due solely to perseveration of position responding, one would not expect to find deficits in a simpler avoidance task, where the animal has to run from one compartment to another, as was

the case in the present study. In the present study, the experimental animals appeared to have difficulty overcoming their initial "freezing" posture; that is, after they had been placed in the shock side of the apparatus, the animals remained motionless until shock was administered, at which time they immediately escaped. This behavior was observed in the operated controls, but only for the first few trials. The fact that neither escape nor avoidance latencies were any different from normal rules out a motor deficiency as the causal factor. Moreover, qualitative observations of the animals' behavior indicate that the CS was eliciting a "fear" response, since the animals typically tensed the body musculature or squealed just prior to shock onset. It appears, then, that the animals were able to learn to fear the onset of the UCS but had difficulty initiating the appropriate motor responses as consistently as normal.

It is interesting that the behavioral symptoms following lesions of either the hippocampus or septum include abnormalities in avoidance responding as well as perseverative problems in positively motivated situations requiring the reversal, alternation, or withholding of a response (Kimble, 1968; McCleary, 1966). MacDougall, Van Hoesen, & Mitchell (1969) have recently compared the behavior of rats with either septal or habenular lesions on a DRL schedule. While the septal animals were grossly impaired in this task, those with habenular lesions showed only a mild and transient deficit. This finding, together with the data on avoidance performance, suggests that the habenular portion of the "limbic system midbrain circuit" is important for the execution of behavior involving shock avoidance but is not importantly involved in other types of limbic operations.

The finding that animals with dorsomedial thalamic lesions are deficient in active avoidance has been repeatedly demonstrated (Vanderwolf, 1962, 1963, 1964). However, in those

experiments, damage extended to the habenula. In the present experiment, lesions of either area alone produced similar results. However, since several nuclei were damaged in the animals with thalamic lesions, it is impossible to determine if any single nucleus was critically involved.

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Table 1
Total Number of Avoidances: Mean
(and Range) Values

Control N = 15	Hab N = 6	DM N = 8	Thal N = 6
52 (47-56)	36 (2-47)	48 (39-54)	23 (0-43)