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The occipito-striate pathway and visual discrimination performance in the white rat

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Discrete bilateral electrolytic lesions destroying the posterior division of the caudoputamen (disconnecting the occipito-striate projection) produces moderate losses in retention of a horizontal-vertical discrimination habit in the rat. Similarly placed lesions had a significantly smaller effect on an equally difficult nonvisual discrimination habit. These results, in conjunction with others, suggest that multiple occipitofugal systems are involved in visually guided behavior.

Webster (1961) has demonstrated that the projection of virtually all cortical areas upon the caudoputamen (CP) is organized on a topographical basis in the rat. With respect to the rostral-caudal dimension, for example, the anterior cortical regions project to the anterior portions of the CP, while the posterior cortical regions give rise to projections to the posterior portions of the CP.

That a cortico-striate pathway may play a significant role in visually guided behavior was first suggested by the finding that lesions to the tail of the caudate nucleus impair visual discrimination learning in monkeys (Divac, Rosvold, & Szwarcbart, 1967). More recently, Livesey and Muter (1976), using the method of electrical (blocking) stimulation, have reported retardation in visual discrimination reversal in rats stimulated within the posteroventral CP.

The purpose of the present study was to determine if lesions to the posterior aspect of the CP in rats would produce a selective deleterious effect on a visual discrimination habit.

METHOD

Adult male albino rats of the Wistar strain were trained to approach a horizontal black-and-white striped card (positive) and to avoid an adjacent vertical black-and-white striped card (negative) in a Thompson-Bryant (1955) discrimination apparatus. Under the motive of escape-avoidance of footshock, a response to the unlocked positive card admitted the animal to the goalbox, whereas a response to the locked negative card was automatically punished by mild footshock. The positive card was switched from the left to the right window in a strict double-alternation sequence. Eight trials were given daily with an intertrial interval of 60 sec. The criterion of learning consisted of no more than one error in 2 consecutive days. Following learning, the majority of rats sustained one-stage bilateral electrolytic lesions to the posterior aspect of the CP; the remaining rats served as the normal control group. After a recovery (or rest) period of 10 days, the animals were given a retention test that consisted of relearning the visual pattern problem. Retention was measured in conventional percentage error savings scores.

Additional rats were used to determine the effects of posterior CP lesions on retention of a nonvisual discrimination habit. They were initially subjected to enucleation of the eyes under deep chloral hydrate anesthesia. After a 2-day recovery period, they were trained on an inclined plane (vestibulo-kinesthetic) problem under the motive of escape-avoidance of footshock to choose the arm that was inclined upward and to avoid the arm that was inclined downward. Eight trials were given daily with an intertrial interval of 60 sec. Specific details of the apparatus and training procedures may be found elsewhere (Thompson, 1978). Following learning (at least 15 correct responses within 2 successive days), the majority of animals sustained bilateral electrolytic lesions to the posterior aspect of the CP; the remainder served as the normal control group. The retention test was given 10 days later; it consisted of relearning the vestibulo-kinesthetic habit.

Upon completion of the retention test, verification of the lesion placements was accomplished (see Thompson, 1978).

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RESULTS

Despite the moderate size of the lesions (see Figures 1A and 1B), the majority of rats suffering posterior CP damage showed no obvious evidence of brain damage by the end of postoperative Day 4, nor did they exhibit any belated symptomatology. The only notable behavioral change involved a tendency toward hyperkinesia.

Table 1 summarizes the learning and retention scores for all groups. With respect to the visual habit, the experimental animals earned significantly lower savings scores than did the controls ($p < .01$, two-tailed Mann-Whitney test). Concerning the vestibulo-kinesthetic habit, the experimental group was also found to be significantly inferior to the control group in retention scores ($p < .05$).

Of particular interest was the finding that posterior CP damage produced greater amnestic effects on the visual discrimination habit than on the vestibulo-kinesthetic discrimination habit: The difference between the means of the two experimental groups was significant at the .02 level. It is important to point out that

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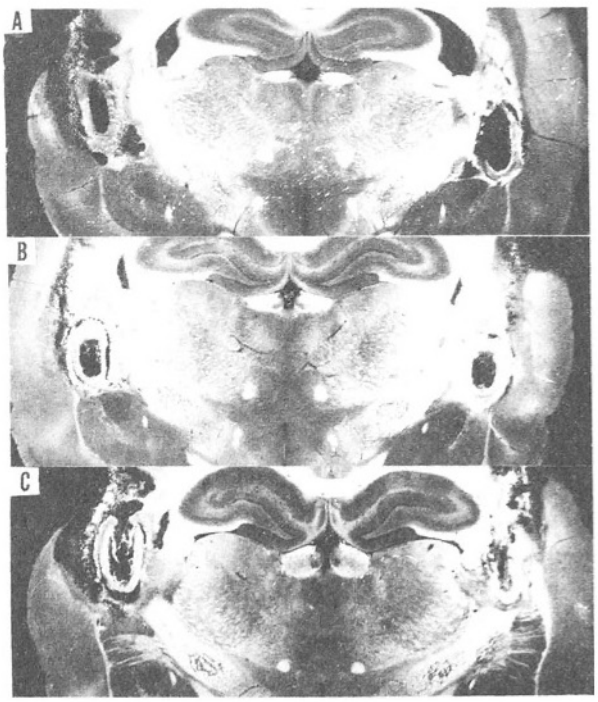

Figure 1. Photographs of unstained sections showing lesions to the caudoputamen in one rat (savings = −100%) trained on the visual problem (A), another (savings = 56%) trained on the nonvisual problem (B), and a third (savings = 60%) trained on the visual problem (C).

Table 1
Mean Learning Errors and Percentage Error Savings for All Groups

		Learning Errors		Error Savings	
Group	N	Mean	Range	Mean	Range
		Visual Problem			
Control	6	17.0	10-26	94.2	85-100
Experimental	10	16.4	8-21	21.8	−100- 64
		Nonvisual Problem			
Control	5	20.0	14-30	97.4	92-100
Experimental	6	15.4	7-23	78.7	46-100

this comparison is reasonably valid to the extent that (1) the vestibulo-kinesthetic habit was virtually of equal difficulty to the visual habit (the former was learned with an average of 17.5 errors and the latter, with an average of 16.6 errors); (2) no significant difference in mean savings scores occurred between the vestibulo-kinesthetic control group and the visual control group; and (3) the posterior CP lesions received by the vestibulo-kinesthetic rats were comparable in both locus and size to those received by the visual rats.

DISCUSSION

The key finding of this study centers on the greater deleterious effects of posterior CP lesions on a visual discrimination habit than on an equally difficult nonvisual discrimination habit. In light of this finding, explanations of the observed visual discrimination impairment cannot readily be ascribed to motivational, emotional, motorial, or intellectual disorders. A sensory disturbance, on the other hand, cannot be entirely ruled out. There was probably partial damage to the projections from the lateral geniculate nuclei, since some of the optic radiation fibers course through the dorsal aspect of the CP (Ribak & Peters, 1975). It is doubtful, however, that injury to the optic radiations is solely responsible for the retention deficit observed on the visual habit. This is suggested by the finding that the two animals with the most dorsally placed CP lesions (see Figure 1C)–thus receiving the greatest damage to the optic radiation fibers and the least damage to the CP–earned the highest savings scores on the horizontal-vertical problem (60% and 64%).

On the whole, these results support the findings of Livesey and Muter (1976) in showing that occipital efferents to the posterior CP play a significant role in visual discrimination performance in the rat. It must be emphasized, however, that occipital efferents to the zona incerta (Thompson & Bachman, 1979) and nucleus cuneiformis of the mesencephalic reticular formation (Petit & Thompson, 1974) may also be implicated in visual discrimination performance. This pattern of results raises the possibility that visually guided behavior may be dependent upon the activation of multiple occipitofugal systems. Further studies will be needed to determine if these different occipitofugal systems mediate different aspects of visually guided behavior in the rat.

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