Effects of choice point lights on T-maze performance by caudate lesioned rats¹

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Rats with bilateral lesions of the caudate nucleus were impaired in a T-maze task requiring them to go toward a light, but not away from a light. The deficit was due to a perseveration of responses to one side of the maze. No correlation was found between the side preferred or reinforced preoperatively and the side preferred during postoperative perseveration.

A T-maze alternation study (Mikulas, 1966) found that choice point lights indicating the correct side improved the performance of caudate-lesioned rats but impaired control rats. The facilitation effect may be because the caudate rats need more information or because the lights are distracting and disrupt perseveration. A recent experiment (Schwartzbaum & Donovan, 1968) found caudate rats impaired in an alternation task based on a brightness discrimination but not one based on a spatial discrimination. This suggests caudate rats don't adequately utilize information from lights in an alternation task and that the T-maze facilitation was due to disruption of perseveration. The present study extends the T-maze findings and attempts to determine any correlations between preoperative behavior and training and postoperative performance.

SUBJECTS AND APPARATUS

Twenty-seven male albino rats weighing 225-250 g at the beginning of the experiment were maintained on ad lib food and 46-h water deprivation during training.

The apparatus, described earlier (Mikulas, 1966), was a T maze with two small lights mounted in the wall at the choice point.

PROCEDURE

During learning of all tasks the rats were run 20 trials a day, every other day. During each trial the rat explored the maze until it entered the "correct" arm, whereupon it was allowed 5 sec of drinking. After 20 trials the rat had 1 h of free access to water in its home cage. Three tasks were used: In the preoperative task "Side" the correct arm for each rat was always on the same side with choice of sides between rats being random. In this task neither choice-point light was on. In the postoperative task "Light-approach" the correct arm was toward the illuminated light. While in the postoperative task "Light-avoid" the correct arm was opposite the illuminated light. In the latter

two tasks which light was on was random across trials. An error was recorded each trial a rat put both front feet into the incorrect arm before the correct arm. In all tasks the rats were trained to a criterion of 9 errorless trials out of 10 unless they did not reach criterion within 200 trials in which case they were given a score of 200.

Two days after a 1-h adaptation in the maze, all rats were trained on task Side. After reaching criterion they were given an additional 100 trials. They were then divided into two groups (caudate and sham). The caudate group consisted of 15 rats which received bilateral radio-frequency lesions of the caudate nucleus 1.5 mm anterior to bregma. The sham group consisted of 12 rats subjected to the same operative procedure as the caudate group except no current passed through the electrodes. After a 2-week recovery period, half of each group was trained on task Light-approach and the other half on task Light-avoid.

1.5 mm anterior to bregma the average caudate lesion was 15% of the caudate. There was associated damage to the internal capsule and occasional damage to the globus pallidus and septal area. Figure 1 shows the range of lesion size on diagrams adapted from DeGroot (1959). The solid area represents the minimum damage and the striped area the maximum. The sham rats had only slight damage to the top of the cortex with no detectable damage to the caudate.

RESULTS

Table 1 shows the mean number of trials to criterion for the four groups of rats trained preoperatively on task Side (top score) and postoperatively on task Light-approach or Light-avoid (bottom score). Ranges of postoperative scores are given in brackets. There are no statistically significant differences between the four groups in their mean number of trials to criterion preoperatively. After randomly discarding animals from each group until there were six in each cell, a 2 by 2 analysis of variance was computed on the postoperative data with type of operation orthogonal to type of task. Statistical significance, with $p < .005$ and $df = 1,30$, was found across the type of operation ($F = 10.8$), the type of task ($F = 16.8$), and the interaction between Operation and Task ($F = 12.9$). Post hoc comparisons between the means show, as is evident from Table 1, that the significant differences may be attributed to the high

Fig. 1. Range of lesion size. Solid area is the smallest lesion, striped area is the largest.

scores of the caudate animals in the Light-approach task. Comparison of this mean with any other corresponding mean is significant at less than the .005 level; while comparison between any other two means is not significant at the .05 level.

The individual protocols indicate that the deficit of the caudate rats on task Light-approach is primarily due to each rat usually first entering the same side of the maze, regardless of the lights, to a much greater degree than the other side. The nature of the task results in such perseveration being reinforced on a variable-ratio schedule. As observed earlier

Table 1
Mean trials to criterion. Top score is preoperative, bottom is postoperative. Ranges of postoperative scores are in brackets.

	Caudate	Sham
Light-Avoid	24.1 28.5 (9-50)	22.2 52.0 (18-78)
Light-Approach	21.6 148.1 (112-200)	23.6 43.0 (25-60)

(Mikulas & Isaacson, 1965), the caudate rats of this study did not begin perseverating until after many postoperative trials.

Individual records of the caudate rats in Light-approach were investigated for any correlation between the preferred side postoperatively and any of the following: the side the rat was trained to preoperatively, the preferred side on the first 15 trials preoperatively, the side the rat went to on the first trial preoperatively, and the preferred side on the first 5 trials postoperatively. None of these showed significant correlation. There was only a slight tendency for postoperative preference to be correlated with the preoperative training side.

A common effect lasting a few days following caudate lesions is a persistent turning toward the side of the greater lesion. Only one of the caudate rats showed any turning and it had little preference for either side in the postoperative task.

Histological examination revealed no significant differences in the size or place of lesions between the two caudate subgroups. Nor was there a correlation between the size or place of lesion and the degree of perseveration.

DISCUSSION

A spatial alternation task (Mikulas, 1966) found that the presence of a choice-point light on the side of the correct arm improved the performance of caudate-lesioned rats. In the present study, using the same apparatus, the caudate rats showed a deficit when required to go toward the side with illuminated light and no deficit when required to go to the side opposite the light. In the present study the rat must attend to the light for correct performance, while in the alternation task the rat could have errorless performance without attending to the lights. Also the postoperative tasks of the present study are probably more difficult for a rat than an alternation task.

The lights may be slightly aversive to the caudate rat. This may be specific to these stimuli or may be because the lights are novel relative to preoperative training. If the lights are aversive, it suggests the following hypothesis: In simple tasks (e.g., spatial alternation) where an aversive stimulus is not a necessary discriminative stimulus, the stimulus may disrupt perseverative tendencies in caudate rats and hence improve their performance. While in more complex tasks where the aversive stimulus is a necessary discriminative stimulus, requiring the caudate rat to approach the stimulus may augment perseveration tendencies.

A second possibility is that since during preoperative training the lights were not on, the rats may prefer the unlit sides postoperatively. This would produce no conflict in task Light-avoid but would in task Light-approach. And this conflict may

produce more perseveration in caudate rats than controls, perhaps because they are more easily frustrated and hence fixate some response (Maier, 1949).

The present experiment has not revealed any way of predicting toward which side the animal will perseverate. Perhaps more intensive preoperative training would have a more determining effect on postoperative preferences.

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NOTE

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Novelty as a basis for the reinforcing effects of saccharine¹

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The purpose of this experiment was to test the hypothesis that the reinforcing effects of saccharine could be, at least in part, understood in terms of stimulus change. Four groups of 20-day-old rat pups were used as Ss. Half of them were reared on 1.3% saccharine solution, and half on tap water for 2 months. At 88 days of age, straight-alley training was given under a 3-h thirst deprivation. Single daily trials for 21 days were received. Half of the saccharine-reared Ss found 1-cc saccharine solution as a reward; half of them found tap water, and similarly for the water-reared Ss. Water-reared Ss ran faster to the saccharine solution, and saccharine-reared Ss ran faster to water than their respective controls.

A phenomenon which has been a puzzle to psychologists for years revolves around the reinforcing qualities of saccharine. Saccharine is a chemical which tastes sweet to human beings, and does not seem to have any nutritive or caloric value as it passes through the organism unaltered. Animals consuming saccharine do not diminish their food intake (Hausmann, 1933). Despite the fact that saccharine has no nutritive value, animals will run mazes, press bars, and perform other instrumental acts when rewarded with it (Carper, 1953; Sheffield, Roby, & Campbell, 1954). This is in direct opposition to the definition of a primary reinforcer as proposed by Hull (1943) and Miller & Dollard (1941).

There have been a number of attempts to explain this instrumental responding in the absence of primary reinforcement. Sheffield & Roby (1950) feel that the possibility of saccharine having an acquired or secondary

reward value is negligible as an explanation of their findings.

Experiments by Guttman (1954), and Hagstrom & Pfaffman (1959) have shown that instrumental response rate is related to the concentration of the solution. Sheffield & Roby (1954) feel that sweet stimulation innately elicits ingestion.

Nachmann (1959), by means of selective breeding, has produced strains of rats with a strong saccharine preference. Nachmann (1957) has also found that the animals raised on saccharine drink less saccharine during testing than the animals raised on water.

A number of investigators have shown that novel stimulation or, more carefully put, "stimulus change" can serve as a reinforcer (Berlyne, 1950; Chapman & Levy, 1957; Glanzer, 1953, 1958). These data, together with Nachmann's observation noted above, suggested to us the possibility of accounting for the reinforcement effects of saccharine in terms of novelty. If novelty is operating, we should find that animals raised on saccharine would find water, following an instrumental response, more rewarding than saccharine.

The purpose of the present experiment was to test this hypothesis.

SUBJECTS

The Ss for this experiment were 40 male albino rats purchased from the Northwest Rodent Company, of Pullman, Washington. They were of weaning age (approximately 20 days old) on arrival and were about 88 days old at the time of testing.

APPARATUS

The apparatus was composed of a start box (SB), two alleyways (A1, A2), and two goal boxes (GB1, GB2) arranged in tandem. The start box and both goal boxes were equipped with guillotine doors. The start box was 12 x 3 x 5 in. and both goal boxes