Differential effects of food deprivation on the fixed ratio behavior of normal rats and rats with septal lesions*

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Rats were given either a septal lesion or operated control treatment and trained to respond reliably on an FR 100 schedule of reinforcement for food reward. Response rates on FR 100 were recorded for both groups as body weight was systematically varied by food deprivation. The response rates of animals with septal lesions increased more rapidly than did those of control animals as a function of increasingly severe levels of deprivation. Results were interpreted in terms of response perseveration and altered metabolism following septal lesions.

Ablation of the septal forebrain results in alterations of performance on many operant tasks. Septal lesions increased the response rate of rats working on CRF and VI schedules for water reinforcement (Harvey & Hunt, 1965), for sucrose-sweetened water (Beatty & Schwartzbaum, 1968), and for food (Lorens & Kondo, 1969). Hothersall, Johnson, & Collen (1970) found that, compared to control animals, rats with septal lesions would work more efficiently and on larger FR schedules for food reinforcement. In each of the above tasks, rapid responding leads to a greater number of reinforcements; however, DRL schedules require response inhibition in order for the animal to work efficiently. Ellen, Wilson, & Powell (1964), Burkett & Bunnell (1966), and MacDougall, Van Hoesen, & Mitchell (1969) observed marked deficits in DRL performance following septal lesions. In many of these studies, McCleary's (1961) motor perseveration hypothesis has been used to explain facilitation or deficits, depending upon the nature of the task. Most of the above studies have held level of deprivation as nearly constant as possible. It is therefore difficult to determine if the changes in performance following septal lesions are due to response perseveration following release from septal inhibition or to differences in the motivational state of the organism as a result of the lesion treatment. In this study, level of deprivation was varied systematically within septal and operated control groups.

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SUBJECTS

Forty male Long-Evans hooded rats, approximately 160 days old, with a mean body weight of 403 g at the beginning of the experiment, were used.

SURGERY AND HISTOLOGY

Twenty animals received septal lesions and 20 received only an incision treatment (operated control group). The lesions were produced using conventional de Groot (1959) coordinates and a current of 2.0 mA, which was passed for 20 sec on each side of the septum. After each animal with a lesion had completed all portions of the task, it was perfused and the brain was sectioned to determine placement and extent of the lesions.

APPARATUS

Three conventional operant chambers were used to train and test all animals. Reinforcements in all phases of the task were 45-mg food pellets.

TRAINING PROCEDURE

The training portion of the task was designed to allow each animal's response rate to stabilize on a FR 100 schedule of reinforcement while a deprivation level of 85% ad lib body weight was maintained. Ad lib body weight was defined as mean body weight over a 7-day period prior to the beginning of training. After determining ad lib weight, animals were placed on a 22-h deprivation schedule and maintained carefully during training at 85% ad lib body weight. Each animal was shaped (3 responses/min for 3 consecutive minutes) and allowed 100 CFR reinforcements. Using Hothersall, Johnson, & Collen's (1970) method, all animals were placed on FR 5 and gradually advanced to FR 100 by the end of 10 h of training. Ten additional hours of training at FR 100 were used

to allow the animals' response rates to stabilize on FR 100 at 85% ad lib body weight. Shaping time, CRF time, and response rate on the last 3 days of FR 100 training were recorded for each animal.

Each animal was then allowed 4 days of ad lib food in order to bring body weight from 85% to near 100% ad lib body weight before testing began.

TESTING PROCEDURE

Ten animals in the septal group and 10 control animals were matched for their FR 100 response rates at 85% ad lib body weight (last 3 days of training). All 20 animals were then carefully deprived of food to produce a controlled weight loss. Rates of response on FR 100 were obtained from each at successively lower body weight (90%, 85%, 80%, 75%, 70%, 65%, 60% ad lib body weight) during 1-h testing sessions. When the animals reached 60% ad lib body weight, the deprivation process was reversed and response rate was measured as each animal regained toward its original ad lib weight. Response rate was recorded for both the septal group and control animals through increasing and decreasing levels of weight loss.

RESULTS

Histology revealed that 80%-100% of the lateral and medial septal nuclei were destroyed. There was little damage to adjacent structures. Septal lesions of the 10 animals which were selected on the basis of their low response rates, did not differ in size or locus from the lesions in animals with high response rates.

Eight of the 10 low-response-rate animals in the septal group were hyperemotional during shaping and CRF portions of the task, but by Day 10 of training, all animals were placid due to handling. The weight of animals in the septal group had not changed significantly from prelesion selection weight following the 21-day recovery period. During the training phase of the experiment, animals in the septal group required less time to reach the shaping criterion than animals in the control group ($t = 9.62$, $df = 38$, $p < .001$). Response rates of the animals in the septal group were higher than in the control group on the CRF portion of the task ($t = 8.70$, $df = 38$, $p < .001$). At the end of training, the mean response rate (last 3 days) on FR 100 for the septal group was 6,113 responses/h and 3,257 responses/h for the control group ($t = 5.14$, $df = 38$, $p < .001$). There was, however, sufficient overlap in response rate to allow selection of 10 control-septal pairs matched for response rate. The data reported next, then, are taken from the 10 fastest responding rats in the control group

Fig. 1. Mean response rate of normal and septal rats on FR 100 through increasing and decreasing levels of deprivation.

and the 10 slowest responding rats in the septal group.

During the testing phase of the experiment, the overall effect of lesion vs control treatment on FR 100 response rate was nonsignificant ($F = 3.17$, $df = 1/19$, $p > .05$). This, of course, is a result of the matching procedure at 85% ad lib body weight level. The high significance of the Groups by Body Weight Levels interaction ($F = 10.4$, $df = 6/108$, $p < .001$) indicates that rate of response for rats in the septal group continued to increase at decreasing levels of body weight (see Fig. 1) after performance in the control group animals had begun to decline. The highest response rate for the septal groups and control occurred at 65% ad lib body weight and 75% ad lib body weight, respectively.

DISCUSSION

Response rate in this study is clearly a function of both level of deprivation

(body weight) and the interaction of Body Weight by Lesion Treatment. Moreover, between-group differences increase as body weight declines. The basic difference in FR 100 response rate (last 3 days of training procedure) between the septal group (all animals included) and the control group supports the response perseveration hypothesis. The interaction of Level of Body Weight by Lesion Treatment, however, supports the hypothesis that motivational processes are altered by septal lesions. This may be related to the alterations in metabolism resulting from septal lesions (Harvey & Hunt, 1965; Lubar, Boyce, Schaefer, 1968; Besch & van Dyne, 1969). Elevated water intake in septal rats may attenuate dehydration associated with food deprivation and thereby protect the septal animals from inanition.

The response perseveration hypothesis does not fully explain the differences in FR behavior observed in

this study. Although the nature of the differential effect of deprivation on rats with septal lesions and control rats is not entirely clear, this study does point out the necessity of controlling deprivation carefully in studies involving septal lesions.

Water regulation data as well as food intake may be important in equating septal and control groups when making comparisons on a food-motivated task.

REFERENCES

- BEATTY, W. W., & SCHWARTZBAUM, J. S. Consummatory behavior for sucrose following septal lesions in the rat. *Journal of Comparative & Physiological Psychology*, 1968, 65, 92-102.
- BESCH, N. F., & van DYNE, G. C. Effects of locus and size of septal lesions on consummatory behavior in the rat. *Physiology & Behavior*, 1969, 4, 953-958.
- BURKETT, E. E., & BUNNEL, B. N. Septal lesions and retention of DRL performance in the rat. *Journal of Comparative & Physiological Psychology*, 1966, 62, 468-471.
- de GROOT, J. The rat forebrain in stereotaxic coordinates. *Verhandelingen Koninklijke Akademie van Wetenschappen, Natuurkunde*, 1959, 52, 1-40.
- ELLEN, P., WILSON, A. S., & POWELL, E. W. Septal inhibition and timing behavior in the rat. *Experimental Neurology*, 1964, 10, 120-132.
- HARVEY, J. A., & HUNT, H. F. Effect of septal lesions on thirst in the rat as indicated by water consumption and operant responding for water reward. *Journal of Comparative & Physiological Psychology*, 1965, 59, 49-56.
- HOTHERSALL, D., JOHNSON, D. A., & COLLEN, A. Fixed ratio responding in normal and septal rats. *Journal of Comparative & Physiological Psychology*, 1970, 73, 470-476.
- LORENS, S. A., & KONDO, C. Y. Effects of septal lesions on food and water intake and operant responding for food. *Physiology & Behavior*, 1969, 4, 729-732.
- LUBAR, J. F., BOYCE, B. A., & SCHAEFER, C. F. Etiology of polydipsia and polyuria in rats with septal lesions. *Physiology & Behavior*, 1968, 3, 289-292.
- MACDOUGALL, J. M., VAN HOESSEN, G. W., & MITCHELL, J. C. Anatomical organization of septal projections in maintenance of DRL behavior in rats. *Journal of Comparative & Physiological Psychology*, 1969, 68, 568-575.
- MCCLEARY, R. A. Response specificity in the behavioral effects of limbic system lesions in the cat. *Journal of Comparative & Physiological Psychology*, 1961, 54, 605-613.