Development of post S^R and post non S^R DRL performance and its retention following septal lesions in rats¹

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Post S^R and post non- S^R responding of rats during the acquisition of a DRL 20-sec schedule was studied. The results support the hypothesis that superior performance following S^R is due to the greater cue value of S^R . Four Ss were then given bilateral septal lesions and retested. The lesion-induced decrement was greater on the post non- S^R distribution, suggesting that septal lesions disrupt the mediating behavioral sequence which fills the temporal interval between responses.

EXPERIMENT 1

Previous investigations (Farmer & Schoenfeld, 1964; Ferraro, Schoenfeld, & Snapper, 1965; Carter & Bruno, 1968) have found that reinforced responses are more likely to occur following reinforced, rather than nonreinforced, responses on the DRL schedule of reinforcement. The inter-response time distribution (IRT) of responses following reinforcement (post- S^R) is sharper and peaks nearer the first reinforced class interval than the IRT distribution of responses following nonreinforced responses (post-non- S^R).

One hypothesis advanced to account for these results is that S^R is a more effective cue for the initiation of ritualized mediating behavior between responses (Carter & Bruno, 1968). In view of the widespread use of the DRL schedule, the authors examined the development of both post- S^R and post-non- S^R components of the schedule.

Method

The Ss were nine male Long-Evans hooded rats maintained on a 22-h food-deprivation schedule. Testing was conducted in two Lehigh Valley operant chambers equipped to deliver 45-mg Noyes food pellets. Operant chambers were enclosed in sound-attenuating, ventilated cubicles. Programming was automated with data collected on two banks of 10 digital counters which provided frequency distributions of responses in 4-sec class intervals.

After adjustment to the deprivation schedule, Ss were shaped to lever-press and allowed to obtain 100 reinforcements on 2 consecutive days. They were then switched to a DRL 20-sec schedule and given 45 daily sessions of 45-min duration. Data were averaged across all Ss within successive two-session blocks. Before averaging, the

IRT data were converted to percentage frequencies.

Results and Discussion

The progressive changes in the IRT distributions for both post- S^R and post-non- S^R responding across training are shown in Fig. 1. The suppressive effect of S^R on 0-4 sec latency responses is immediately apparent. This cannot be attributed solely to eating time, since this behavior requires only 1 sec for completion. In contrast, 0-4 sec responding following post-non- S^R responses showed only a gradual decline, and at terminal performance continued to account for 24% of all post-non- S^R responses. It was observed that short-latency responses were most likely to occur in bursts following a long-latency response slightly less than criterion length. This phenomenon may be similar to the frustration effect seen in double-alley studies.

Further comparative statements regarding post- S^R and post-non- S^R distributions are difficult to make in view of the interdependence of frequencies in different class intervals. Hence, the data were converted to IRTs/Opportunity (Anger, 1956). This conversion eliminates frequency dependencies between response interval classes by defining the response probability for each interval relative to the total number of responses made in that and subsequent intervals. Examination of Fig. 2 indicates that with the exception of the first session block, superiority of temporal discrimination (as indicated by the magnitude of the slope) following S^R developed immediately and was most pronounced in the range from 4 to 20 sec. Maximal differences in accuracy between the two components occurred at approximately 13-16 days. Thereafter, the post-non- S^R distribution approached the form of the post- S^R distribution. Statistical comparisons of class intervals for the final two training sessions using the Walsh test for correlated scores (Siegel, 1956) indicated that post-non- S^R distributions differed from post- S^R distributions for the four class intervals from 0 to 16 sec ($p < .02$).

Session-to-session changes in percentage of reinforced post- S^R and post-non- S^R responses were compared using the Walsh test. In view of the large number of 0-4 sec responses which occurred in post-non- S^R responding, this interval was eliminated in calculating the percentage reinforcements. In spite of this, post- S^R responses were more likely ($p < .02$) to be reinforced than

Fig. 1. Development of post S^R and post non- S^R IRT distributions across 45 training sessions. The data are plotted at the upper limit of the class interval.

post-non- S^R responses for all but the first 5 days of training.

Thus, these results are consistent with the hypothesis that stimulus control exerted by S^R and subsequent mediating sequences provide considerable control over timing behavior. The lack of such control after post-non- S^R may result from the initiation of timing behavior at variable points in the established mediating sequence of ritualized behaviors.

EXPERIMENT 2

Septal lesions typically disrupt DRL behavior (Burkett & Bunnell, 1966; MacDougall, Van Hoesen, & Mitchell, in press). These results have led to the suggestion that septal lesions disrupt central mechanisms enabling the S to inhibit high probability responses (McCleary, 1966).

In view of the results of Experiment 1, the response-inhibition hypothesis suggests two possible opposing outcomes. First, if the S has impaired ability to withhold responding, the lack of a clearcut discriminative cue following nonreinforced responses should be particularly debilitating. Second, it might be argued that if an S is unable to withhold responding, a reinforced response should markedly increase the probability that a lever press will occur with a short latency. This experiment investigated these alternatives.

Method

Four Ss from the previous experiment

Fig. 2. Development of post SR and post non-SR IRT/Opportunity distributions across 45 training sessions. The data are plotted at the upper limit of the class interval.

were used. Following the 45 training sessions all Ss were allowed 2 days of ad lib feeding, then anesthetized with Nembutal and given bilateral lesions of the septal nuclei. The lesions were created by passing 1.5-mA anodal dc for 20 sec through the uninsulated tip of a stereotaxically guided stainless-steel electrode. Coordinates were 1.5 mm A, .5 mm L, and 6.0 mm D, with respect to the bregma, and with the head at a 5-deg angle to a horizontal plane. After surgery 30,000 units of Bicillin were administered.

Postoperatively Ss were allowed 3 days of ad lib feeding, followed by 3 days of readjustment to the deprivation schedule. After 12 daily test sessions on the DRL 20-sec schedule they were anesthetized with an overdose of Nembutal and perfused with saline and formalin. The brains were removed, fixed in acid formalin, dehydrated in pyridine, embedded in celloidin, and sectioned at 15 μ . Sections throughout the lesion were stained with cresyl violet and Luxol fast blue MBS.

Results and Discussion

The lesions were similar to many previously described in the literature. Damage started anterior to the genu of the corpus callosum and extended posteriorly to the columns of the fornix. In all Ss the lateral and medial septal nuclei were destroyed, but some supracommissural septal tissue remained intact.

The pre- and postoperative IRT/Opportunity results are presented in Fig. 3. They are based on all Ss and averages of 6 and 12

sessions, respectively. Postoperatively all Ss were deficient in inhibiting short- and medium-latency responses, with the response probability increasing with the time since a previous response. The effects were more marked for the post-non-SR component, suggesting that the cue value of SR partially counters the lesion-induced effects.

Comparison of response probabilities using the Walsh test indicated that the response probabilities for the 4-8 sec, 8-12 sec, 12-16 sec, and 16-20 sec intervals were significantly greater in their magnitude of change for the post-non-SR distributions ($p < .062$). Similar results were found for percentage of reinforced responses. In all Ss the decreases were greater for the post-non-SR component. Of interest is the slight decrease in the number of 0-4 sec latency post-non-SR responses following the lesions. If such responding reflects frustrative behavior, their decrease in frequency following lesions would suggest that affective changes are not responsible for the observed deficit.

The results suggest that a significant portion of the septal deficit in DRL responding results from a disruption of ritualized mediating behavior between responses and not disinhibition of lever pressing entirely. Such a deficit might include the omission of particular behavioral sequences or a tendency to terminate such sequences prematurely.

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NOTES

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Stimulus compounding with an instrumental avoidance response

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A light and buzzer each separately maintained a latency of response which avoided shock in a shuttle box. When the light and buzzer were compounded, the latency was significantly shorter than the latency to either single stimulus. This result

reliably occurred only with Ss that had a high percentage of avoidance responses and fairly short latencies to the single stimuli. The results were interpreted in terms of summation of response tendencies.

When two conditioned stimuli, each capable of maintaining a response, are