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NOTE

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Olfactory cues and spontaneous alternation behavior¹

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Experiments were conducted to determine the effect of reward and drive on spontaneous alternation behavior (SAB) across trials. It was suggested that reinforcing severely food-deprived rats reduced SAB across trials when direction was the sole relevant cue, but no reduction was found when odor cues were present. It was shown that SAB decreases as a function of both days and trials of training.

In 1952, Montgomery suggested that spontaneous alternation behavior (SAB) was a result of an exploratory tendency. Using a cross-maze, Montgomery (1952) found that rats performed the same body-turn response in order to enter different goal arms. Montgomery (1952) proposed that SAB was a special case of the rat's exploratory tendency, i.e., the novelty and hence the attractiveness of the goal entered on Trial 1 diminishes relative to the goal arm not visited.

Recently Douglas (1966) demonstrated that rats avoid their own odor trail. Since Montgomery (1952) used a procedure that did not control for odor trail, one might hypothesize that the Ss in his experiment were either avoiding their own odor and/or using odor as a discriminative cue for exploration. This study was designed to determine if, indeed, Montgomery's results might better be explained in terms of odor trail.

EXPERIMENT 1

Subjects

The Ss were 4 experimentally naive hooded rats and 16 albino rats approximately 90 days old.

Apparatus

A cross-maze was constructed of unpainted white pine. All maze compartments were 2 in. wide and 4 in. high. The start and goal boxes were 8 in. long and the start and goal arms were 14 in. long. A plywood panel was used to block off one of the starting stems, at the choice point, thereby converting the cross into a T-maze. A wire mesh top covered the maze. The maze was placed on the floor of an 8 x 8 ft windowless room, illuminated by a 15-W bulb suspended 3 ft above the choice point.

Procedure

Preliminary training consisted of 5 days of gentling followed by 2 days of six reinforced trials per day in a straight-alley maze (4 ft x 2 in. x 4 in.). During Preliminary Training Days 1-5, Ss were maintained on a daily ad lib water schedule and 9-g Rockland lab chow. On Preliminary Training Days 6 and 7 and Experimental Days 1-4, Ss were food-deprived except for the food consumed during training. Because of the Ss' apparent weakness they were given 4 g of lab chow, in their home cages, during Experimental Days 5 through 7.

Five Ss were randomly assigned to four groups; each group contained one hooded and four albino rats. The experiment consisted of a 2 by 2 design with two types of trial order and two odor trail conditions. The first letter (S or C) refers to the trial starting stem order (successive or counterbalance) and the second (P or A) refers to the presence or absence of S's own odor

trail. Groups S-P and S-A day's run began from one start stem direction [e.g., (N)] for six successive trials then from the opposite start stem direction the next day [e.g., (S)]. Groups C-P and C-A starting stem was varied within a day's run [e.g., (S), (N), (N), (S), (S), (N)]. Odor trail presence or absence was manipulated in the following manner: Clean heavy brown paper inserts, covering the floor and walls of the goal arms, were used on Trial 1 each day. During each ITI for Group P, clean brown paper was inserted in the goal arm *not* visited so that there was always a "fresh" odor-trail goal arm and "clean" one. The brown paper inserts were changed in *both* arms at the end of each trial for Group A.

For 7 days each S was given six trials a day, thereby providing an opportunity for 35 goal-arm and/or odor-trail alternation responses. Animals received about 300-mg lab chow for entering either goal arm. The ITI ranged from 5 to 10 sec. A wooden block between the choice point and the goal arms prevented retracing.

Results

SAB was evaluated using a χ^2 test comparing the observed distribution of alternation and nonalternation responses with a distribution based upon chance expectancies. A χ^2 test was used for each of the four groups, the tests revealed that Groups S-P and C-P demonstrated SAB (79% and 72% alternations with $\chi^2 = 19.68$, $df = 1$, $p < .01$ and $\chi^2 = 9.94$, $df = 1$, $p < .01$, respectively), but Groups S-A and C-A did not demonstrate SAB (46% and 44% alternations with $\chi^2 = .64$, $df = 1$, $p > .10$ and $\chi^2 = 1.26$, $df = 1$, $p > .10$, respectively). A *t* test comparing the number of goal-arm alternation responses between the successive and counterbalance trial order procedures (S and C) was statistically nonsignificant ($p > .05$).

Discussion

Experiment 1 suggested that Montgomery's (1952) SAB finding was probably due to the rats' utilizing their own odor trails. The present study supported Douglas' (1966) demonstration that rats avoid their own odor trail at a higher-than-chance rate. However, Douglas (1966) also found that rats showed SAB to direction, e.g., east (E) and west (W), when no other cues were present. Thus, the control groups (Groups S-A and C-A) in this experiment should have demonstrated an above-chance rate of alternation behavior to the direction cue; these groups were in fact slightly below chance.

EXPERIMENT 2

In Experiment 1, Ss that were presented with direction as the sole cue failed to demonstrate SAB although Douglas (1966) found that Ss showed SAB to direction at a rate of about 63.5%. The purpose of

Experiment 2 was to identify the variable or variables that contributed to this variant finding. There were at least three factors that differed between Experiment 1 and Douglas' (1966) study: (1) In our experiment Ss were maintained on a food-deprivation schedule, while Douglas' Ss were satiated; (2) Rats were reinforced in the former but not in the latter study; and (3) Experiment 1 consisted of six trials per day for 7 days whereas Douglas (1966) employed a two-trial per day procedure.

Subjects

The Ss were 24 100-day-old experimentally naive albino rats.

Apparatus

The apparatus used in Experiment 1 was employed in this study.

Procedure

The preliminary training procedure was the same as in Experiment 1, except that all Ss were maintained on 9-g lab chow per day throughout preliminary training. The design consisted of a 2 by 2 factorial with two levels of reward, 0 or 250 mg of lab chow, and two levels of food deprivation, 0 or 23 h. The first number designates reward magnitude (0 or 250) and the second the number of hours of food deprivation (0 or 23). The four groups were Groups 0-0, 0-23, 250-0, and 250-23.

Subjects were run six trials per day for 7 days. Although the ITI was maintained at 10 sec, nonreinforced and satiated Ss traversed the maze more slowly than reinforced and satiated animals. This decrement in running speed was assumed unimportant in determining SAB since Gross, Black, & Chorover (1968) recently demonstrated that ITIs ranging from 0 to 15 min had no effect on SAB.

All 24 Ss followed the same start stem randomization order for the 42 experimental trials; a Fellows (1967) randomization series was employed for this purpose. Paper floor lining in both goal arms was replaced with clean sheets during the ITI. Reinforced animals were given 250 mg of lab chow for either goal arm entry and 20 sec to consume the food.² Food-deprived Ss were 23-h food-deprived, and the satiated rats were given continual free access to food.

Results

The 24 Ss combined in one chi square test did not demonstrate SAB over the seven experimental days ($SAB = 56\%$; $\chi^2 = 1.44$, $df = 1$, $p > .05$). However, individual χ^2 tests revealed statistically significant SAB for the reinforced Ss (SAB for Group 250-0 = 61% and Group 250-23 = 60% ; $\chi^2 = 4.84$, $df = 1$, $p < .05$ and $\chi^2 = 4.00$, $df = 1$, $p < .05$, respectively) and a lack of SAB for the nonreinforced Ss (SAB for Group 0-0 = 51% and Group 0-23 = 53% ; $\chi^2 = .04$, $df = 1$, $p > .05$, respectively). An analysis of

variance was performed on the group alternation scores across the 7 days; the reinforcement and trials main effects were statistically significant ($F = 5.33$, $df = 1/20$, $p < .05$ and $F = 5.94$, $df = 6/120$, $p < .001$, respectively). Therefore, reinforced Ss alternated to direction cues at a higher rate than nonreinforced ones and SAB dissipated over days. A matched t test was performed on the total number of alternation responses for the 1st vs the 7th experimental day ($t = 3.83$, $df = 23$, $p < .005$); the former showed a greater number of alternation responses than the latter. A χ^2 test revealed that the alternation rate on the 1st day was above chance ($SAB = 68\%$; $\chi^2 = 12.96$, $df = 1$, $p < .001$) but on the 7th day at chance level ($SAB = 49\%$; $\chi^2 = .04$, $df = 1$, $p > .05$).

Since SAB was found to decrease over days one may also speculate that alternation decreases over trials within a daily session. There were five possible alternation opportunities per animal each day. Combining all first alternation opportunities (FAO) for the 7 days and all last alternation opportunities (LAO) provided a means of assessing the probability of SAB as a function of trials per day. A matched t test showed that during FAO there were significantly more alternations than during LAO ($t = 1.91$, $df = 23$, $p < .05$); SAB was above chance level for the FAO scores ($SAB = 65\%$; $\chi^2 = 9.00$, $df = 1$, $p < .01$) but not for the LAO data ($SAB = 57\%$; $\chi^2 = 1.96$, $df = 1$, $p > .05$).

To assess direction as a cue for SAB Douglas (1966) used two mazes placed in opposite directions in the same room and found that rats alternated at a rate of about 63.5%. Douglas' Ss were satiated, nonreinforced, and run in only two sessions. The present experiment Group 0-0 FAO alternation scores are most analogous to Douglas' data. The percentage of alternation responses for the Group 0-0 FAO scores was 66.7% ($\chi^2 = 10.20$, $df = 1$, $p < .01$).

DISCUSSION

The results of Experiment 2 showed that practice trials had a negative effect on albino rats' SAB when the sole cue present was direction. This demonstration was consistent with Spear, Hill, & O'Sullivan's (1963) findings with albino rats. It was also shown that moderate amounts of reinforcement facilitated SAB, a finding supported by Walker (1956).

In 1955 Bruner, Matter, & Papanek proposed that drive conditions may influence cue utilization, i.e., Ss under varying drive levels attend to specific cues at different probability levels. The results of Experiments 1 and 2 support this hypothesis when applied to SAB. In a post hoc analysis of the results of Experiments 1 and 2 a Cue by Motivation interaction is suggested. In Experiment 1, severely food-deprived, rein-

forced Ss were presented with direction as the sole relevant cue and failed to maintain SAB above chance levels, yet under low or moderate deprivation states, in Experiment 2, reinforced Ss demonstrated SAB. This finding, at least for direction cues, is consistent with Dember & Fowler's (1958) "empirical generalization" that severe deprivation conditions have a negative effect on SAB. However, severe drive conditions may have a position effect on SAB when odor trail cues are present. For example, Douglas (1966) found that satiated rats showed SAB to odor trail cues at a 65.6% level while our study's severely deprived Ss' SAB was about 10% higher ($\bar{X}$ Groups S-P and C-P = 75.5% alternations) after repeated trials. Accepting this comparison with caution, one may postulate that under severe drive conditions odor trail outweighs the importance of directional cues with the converse being true under low-to-moderate drive conditions. Intuitively, one might suspect that olfactory stimuli, because of their association with food, should be a predominant cue during severe drive states.

In both Experiments 1 and 2 it was shown that practiced Ss did not demonstrate SAB to directional cues across trials and days. However, SAB was found in Experiment 2 when FAO scores were analyzed. These results restrict Douglas' (1966) findings of SAB due to direction cues to cases where limited practice is allowed.

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NOTES

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2. Although records were not kept, it was observed that satiated reinforced animals (Group 250-0) occasionally either nibbled at, or picked up, the food pellets in the goal box.