Learning to escape cues paired with reward reductions following single- or multiple-pellet rewards

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In Experiment 1, three groups of rats were given 60 runway acquisition trials (6/day) to either one 500-mg pellet (Group 1L), 25 20-mg pellets (Group 25S), or one 20-mg pellet (Group 1S). Rate of approach to asymptote was faster for Group 25S than for Group 1L, and at asymptote, they ran faster than Group 1S. All groups then received one 20-mg pellet for 30 trials. Group 25S showed a greater depression effect than did Group 1L. The acquisition results were replicated in Experiment 2, and, during a third phase in which Ss were given hurdle-jump training, both shifted groups jumped faster than Group 1S, but Group 25S jumped the fastest. It was concluded that greater amounts of frustration are elicited when both reward magnitude and number of pellets are reduced than when only reward magnitude is reduced.

Many studies have demonstrated that the strength of a simple instrumental response at asymptote is directly related to the magnitude of the reward received (cf. Bitterman & Schoel, 1970). McCain (1969) has pointed out, though, that many of them have confounded reward magnitude with number of pellets. Recent studies which have equated groups for number of pellets by using one large and one small pellet have not obtained differences at asymptote between groups receiving different reward magnitudes (e.g., Black, 1969; McCain, Dyleski, & McElvain, 1971). When reward magnitude has been equated but number of pellets has varied, the group receiving many small pellets has performed more rapidly than the group receiving one large pellet (McCain, 1969). Although McCain (1969) found these differences to be significant at asymptote, Amsel, Surridge, & Hug (1969) and Traupmann (1971) found that differences did not appear, or disappeared, with more extended training. Many incentive-shift experiments (cf. Crespi, 1942) have confounded reductions in magnitude of reward with reductions in number of pellets, although the depression effect has been obtained when reward magnitude was reduced from one large pellet to one small pellet (e.g., Spence, 1956).

The purposes of the present experiments were: (1) to provide additional data on the effects of reward magnitude with number of pellets equated and on the effects of multiple- vs single-pellet rewards with

reward magnitude equated, (2) to determine if the magnitude of the depression effect is influenced by multiple- vs single-pellet rewards in acquisition, and, if so, (3) to measure whether or not the difference in the magnitude of the depression effect is due to amount of frustration elicited during the incentive-shift phase. This was done by measuring the rate of learning of a new response (hurdle-jump response) to escape the cues paired with the reduced reward.

SUBJECTS

In Experiment 1, male Holtzman rats ($N = 45$, $n = 15$) obtained from Holtzman Co., Madison, Wisconsin, 85-99 days old, weighing 340-398 g prior to deprivation, were fed Big Red laboratory rat chow for 1 h/day, which reduced Ss to 86% of their original body weights. In Experiment 2, male Holtzman rats ($N = 42$, $n = 14$) approximately 95 days old, weighing 315-379 g prior to deprivation, were fed Big Red laboratory chow for 50 min/day, which reduced Ss to 84% of their original body weights. The mean weights of the various groups did not differ from each other during the course of the experiments, $F_s < 1$.

APPARATUS

The white alley consisted of a 30.5-cm startbox, 139.7-cm runway, and 27.9-cm goalbox, 14.0 cm high and 11.4 cm wide. A startbox door which opened sideways controlled the start of each trial and activated a silent switch connected to a Hunter Klockounter. Interruption of photobeams, 15.2 cm, 137.2 cm, and 157.5 cm from the door and connected to Hunter photorelays and Klockounters, measured start, runway, and goal times, respectively. Interruption of the last photobeam controlled the onset of a light in the

goalbox during the appropriate phases of Experiment 2. A goalbox door prevented retracing. The Ss received the designated number of pellets (P. J. Noyes Co., Formula A) in a white measuring spoon hanging from the wall at the end of the alley on the left side, 8.26 cm from the floor. The spoon was bent up so that it was impossible for Ss to see the pellets before they broke the last photobeam. Sanded Plexiglas covered the alley.

In Experiment 2, the hurdle-jump section was also used. This section consisted of a startbox (which was the goalbox of the alley) and a goalbox which was attached to the end of the startbox. The start- and goalboxes were separated by a door (10.2 x 6.4 cm) which rested on a hurdle, 5.1 cm high, and opened in an upward direction. The goalbox of the hurdle-jump apparatus (11.4 x 27.9 x 14.0 cm) was painted medium gray and had a wire mesh top with sanded Plexiglas above it. The time from raising the door to the breaking of a photobeam 10.2 cm from the hurdle was measured by a Hunter Klockounter.

PROCEDURE

Eight days following the beginning of the deprivation schedule in Experiment 1, Ss were taken to the experimental room and placed in an unpainted wooden box (26.7 x 11.4 x 15.2 cm) with a wire mesh top and solid bottom and received in an unpainted measuring spoon the number and size of pellets they would receive in the alley. On the next day, Phase 1 of the experiment began. All Ss received two trials in the alley on the first day, four trials the next day, and six trials per day thereafter. A trial began with S being placed in the startbox. After S had faced the startbox door for 3 sec, the door was opened and S was allowed to run down the alley. The goalbox door was closed when the last photobeam was broken. Group 1L received one large (500-mg) pellet, Group 25S received 25 small (20-mg) pellets, and Group 1S received one small (20-mg) pellet on every trial. Groups 1L and 25S were removed from the goalbox when they finished eating, and Group 1S was left in the goalbox for approximately 10 sec and then returned to retaining cages (water available). On the 5 days following the 60th acquisition trial, all Ss were given six trials per day and received one small pellet (Phase 2). All Ss were removed from the goalbox after 10 sec.

The procedure used in Experiment 2 was identical to that of Experiment 1, except that (1) on the day before the beginning of Phase 1, Ss were placed in the goalbox of the

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Fig. 1. Mean start, runway, and goal speeds (1/sec) per day (six trials/day) for the acquisition and shift phases of Experiment 1.

hurdle-jump apparatus for 7 min, (2) during Phase 2, Ss received only 1 day of training (six trials) and a light came on in the goalbox of the alley as S broke the third photobeam, and (3) Ss were given 2 days of hurdle-jump training (15 and 12 trials/day, respectively) following Phase 2 (Phase 3). During Phase 3, S was placed in the startbox of the hurdle-jump apparatus (the goalbox of the alley) and the light came on. Ten seconds later the door was raised. After jumping, S remained in the goalbox of the hurdle-jump apparatus for 10 sec and was then returned to the retaining cages. If S did not jump within 60 sec, he was removed from the startbox and a latency of 60 sec was recorded. All Ss received one small pellet in the startbox of the hurdle-jump apparatus during Phase 3.

The Ss were run in squads of nine, three Ss from each group, with an intertrial interval of 6-7 min during Phases 1 and 2 and 5-8 min during Phase 3. The order of Ss run within each squad was random but remained constant over days. Two Es ran all Ss. However, both Es handled Ss prior to

the acquisition phase, and no E ran an S for more than 2 days in a row.

RESULTS

Mean speeds (1/sec) per day for the runway acquisition and the incentive shift phases are presented in Fig. 1 for Experiment 1 and in Fig. 2 for Experiment 2. Groups by Days (3 by 10) analyses of variance done on Phase 1 data indicated a significant groups effect, $F(2,42) = 35.72, 60.52,$ and $42.77, p < .001$, a significant days effect, $F(9,378) = 200.42, 162.89,$ and $97.78, p < .001$, and a significant Groups by Days interaction, $F(18,378) = 4.06, 4.32,$ and $3.81, p < .001$, for the start, runway, and goal measures, respectively, for Experiment 1, and a significant groups effect, $F(2,39) = 61.10, 28.56,$ and $27.74, p < .001$, a significant days effect, $F(9,351) = 126.65, 225.29,$ and $130.27, p < .001$, and a significant Groups by Days interaction, $F(18,351) = 2.53, 5.86,$ and $5.04, p < .001$, for the start, runway, and goal measures, respectively, for Experiment 2. To test for groups effects early, middle, and late in training, separate simple analyses of variance were done on the data for Days 1, 6, and 10. On Day 1 data, there were no groups effects, $F_s < 1$, on the start and runway measures for Experiments 1 and 2, but on the goal measure, there was, $F(2,42) = 7.17, p < .01$, for Experiment 1 and $F(2,39) = 4.66, p < .05$, for Experiment 2. Newman-Keuls tests ($p = .05$) indicated that on the goal measure, Group 1S ran more slowly than the other two groups in Experiment 1 and Group 1S ran more slowly than Group 25S in Experiment 2. However, an analysis of Trial 1 data indicated no significant differences among the groups for Experiments 1 and 2, $p_s > .05$. On Day 6 data, there were significant groups effects, $F(2,42) = 16.97, 18.33,$ and $33.67, p < .001$, for the start, runway, and goal measures, respectively, for Experiment 1 and $F(2,39) = 26.96, 15.11,$ and $50.55, p < .001$, for the start, runway, and goal measures, respectively, for Experiment 2. Newman-Keuls tests ($p = .05$) indicated that on the start and runway measures, Groups 1L and 25S ran faster than Group 1S but did not differ from each other in both Experiments 1 and 2. On the goal measure, Group 25S ran faster than Groups 1L and 1S and Group 1L ran faster than Group 1S in both experiments. On Day 10 data, there were significant groups effects, $F(2,42) = 21.62, 26.26,$ and $19.96, p < .001$, for the start, runway, and goal measures, respectively, in Experiment 1 and $F(2,39) = 13.71, 17.28,$ and $11.99, p < .001$, for the

Fig. 2. Mean start, runway, and goal speeds (1/sec) per day (six trials/day) for the acquisition and shift phases of Experiment 2.

start, runway, and goal measures, respectively, for Experiment 2. Newman-Keuls tests ($p = .05$) indicated that Groups 1L and 25S ran faster than Group 1S but did not differ from each other on all response measures in both experiments.

Groups by Days (3 by 5) analyses of variance done on the Phase 2 data of Experiment 1 indicated a significant groups effect, $F(2,42) = 4.38, 17.48,$ and $4.20, p < .05$, and a significant days effect, $F(4,168) = 13.19, 12.28,$ and $85.02, p < .001$, for the start, runway, and goal measures, respectively. The Groups by Days interaction was also significant on the start and runway measures, $F(8,168) = 3.93$ and $6.87, p < .001$, but not on the goal measure, $F(8,168) = 1.52, p > .05$. Separate simple analyses of variance on Day 3 data indicated significant groups effects, $F(2,42) = 6.41, 7.35,$ and

Fig. 3. Mean hurdle-jump speeds (1/sec) per three-trial blocks for the first and second day of hurdle jumping of Experiment 2.

4.29, $p < .05$, for the start, runway, and goal measures, respectively. Newman-Keuls tests ($p = .05$) indicated that: (1) on the start measure, Group 25S ran more slowly than Groups 1L and 1S, (2) on the runway measure, Group 25S ran more slowly than Group 1S, and (3) on the goal measure, Groups 25S and 1L both ran more slowly than Group 1S. Analyses of variance on Day 5 data indicated that there were no group differences on any measure, $F_s < 1$.

Mean speeds (1/sec) of hurdle jumping for Experiment 2 per three-trial blocks are presented in Fig. 3. A Groups by Trial Blocks analysis of variance (3 by 9) indicated a significant groups effect, $F(2,39) = 17.67$, $p < .001$, a significant trial blocks effect, $F(8,312) = 8.51$, $p < .001$, and a significant Groups by Trial Blocks interaction, $F(16,312) = 2.02$, $p < .05$. Because of the significant interaction effect, separate analyses of variance were done on each trial block. There were no groups effects on Trial Blocks 1, 8, or 9, $F(2,39) = 1.13$, 2.86, and 2.95, $p > .05$, respectively. However, there were significant groups effects on Trial Blocks 2, 3, 4, 5, 6, and 7, $F(2,39) = 4.91$, 4.79, 6.00, 10.51, 16.08, and 7.21, $p < .05$, respectively. Newman-Keuls tests ($p = .05$) indicated: (1) Groups 25S and 1L jumped faster than Group 1S on Trial Block 2, (2) Group 25S jumped faster than Group 1S on Trial Blocks 3 and 4, (3) Group 25S jumped faster than Groups 1S and 1L on Trial Block 5, (4) Group 25S jumped faster than Groups 1L and 1S and Group 1L jumped faster than Group 1S on Trial Block 6, and (5) Groups 25S and 1L jumped faster than Group 1S on Trial Block 7.

DISCUSSION

The present data support the position that asymptotic performance of an instrumental response is a function of reward magnitude and that number of pellets only influences rate of approach to asymptote. Following 60 acquisition trials (a sufficient number to reach asymptote according to McCain et al, 1971), Groups 25S and 1L did not differ from each other, although Group 25S ran faster than Group 1L on the goal measure halfway through training. Groups 25S and 1L ran faster than Group 1S on all three measures throughout acquisition. The lack of difference between Groups 1L and 25S at the end of acquisition on the goal measure must be accepted with caution, however, since the graph does indicate a small difference. However, these data agree with those of Amsel et al (1969) and Traupmann (1971) and not with those of McCain et al (1971). Additional research will have to be done to determine what procedural variations are causing the differences among the results of the studies. Possible differences include time in the goalbox (e.g., Cilluffo & Black, 1970), number of acquisition trials, time vs speed scores (Traupmann & Wong, 1971), type of deprivation schedule, and exploration of the unbaited runway prior to acquisition.

According to frustration theory (Amsel, 1958; Daly, 1969), the depression effect is due to the elicitation of the aversive motivational response, frustration, when a small reward is experienced in the presence of cues conditioned to elicit an expectancy of a large reward during acquisition. The frustration response becomes conditioned to the cues of the goalbox and through stimulus

generalization is elicited earlier in the alley. The competing responses associated with frustration disrupt approach behavior. This disruption is measured by comparing the speeds of the shifted group with those of a control group that is conditioned throughout training to expect the small reward. The results of Experiment 1 indicated that when number of pellets was held constant, reductions in reward magnitude resulted in frustration, since Group 1L ran more slowly than Group 1S in the shift phase. However, Group 25S showed a greater depression effect on the start and runway measures than did Group 1L, indicating that a shift in number of pellets in addition to a reduction in reward magnitude aroused a greater amount of frustration than when only the reward magnitude was reduced.

Speed of hurdle jumping is presumed to reflect the amount of frustration aroused by the small reward and has been shown to be a good measure of frustration aroused in other change-in-reward studies (e.g., Daly, 1969). During the hurdle-jump phase of Experiment 2, Groups 1L and 25S jumped the hurdle faster than Group 1S, but Group 25S jumped faster than Group 1L. These data provide additional evidence for the conclusion that greater amounts of frustration are elicited when both reward magnitude and number of pellets are reduced than when only reward magnitude is reduced.

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