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Influence of reward magnitude on the initial nonreward effect*

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Two groups received 20 nonrewarded (N) runway trials followed by either 20 small-reward (2 pellets) or 20 large-reward (20 pellets) trials (Groups N-2 and N-20, respectively). Groups receiving 40 small-reward (Group 2-2) or 40 large-reward (Group 20-20) trials were also included (N = 10 rats/group). An initial nonreward effect (INE) was obtained, with Groups N-2 and N-20 being more resistant to extinction than Groups 2-2 and 20-20, respectively. The size of the INE was independent of reward magnitude, and small-reward groups were more resistant to extinction than large-reward groups.

Groups given a block of nonrewarded trials, not preceded by rewarded trials (initial nonrewards), but followed by continuous reinforcement (CRF) have been found to be more resistant to extinction than groups given CRF alone (Robbins, Chait, & Weinstock, 1968; Spear, Hill, & O'Sullivan, 1965; Spear & Spitzner, 1967). The increased resistance to extinction (R to E) produced by initial nonrewards has been called the initial nonreward effect (INE). The studies cited above employed a substantial number of initial nonrewards, but a small-trial INE has been obtained when very few initial nonrewards and subsequent CRF trials were used (Capaldi & Waters, 1970; Capaldi, Ziff, & Godbout, 1970; McCain, 1966).

The purpose of the present experiment was to determine the effects of reward magnitude on the INE. As an initial nonreward–CRF sequence constitutes a form of partial reinforcement (PRF), it would be useful to know whether the INE and the partial reinforcement extinction effect (PREE) are similarly influenced by reward magnitude. Hulse (1958) and Wagner (1961) reported that under PRF, R to E was an increasing function of reward magnitude while under CRF, R to E was inversely related to reward magnitude. Hence, in those investigations, the PREE was larger with large reward than with small reward.

In the present experiment, the effects of reward magnitude were examined for groups shifted from nonreward in Phase 1 to either 2 or 20 pellets reward in Phase 2. These groups were compared during extinction to groups given either 2 or 20 pellets reward in both Phase 1 and Phase 2.

METHOD

Subjects

The Ss were 40 naive male albino rats approximately 80 days old when received from the Holtzman Co., Madison, Wisconsin.

Apparatus

The apparatus consisted of a runway, 208.4 cm long x 22.9 cm high x 10.2 cm wide, with a hinged lid of 1.3-cm hardware cloth; it was painted flat gray throughout. A 20.3-cm-long floor treadle suspended over a microswitch constituted the initial portion of the alley. When the treadle was depressed by the weight of the rat, the first .01-sec clock was started. The clocks were operated by photoelectric circuitry, with start, run, and goal times being measured over the first 5.1 cm beyond the forward edge of the treadle, the next over 132.1 cm, and finally over a 39.4-cm section, respectively. When the goal clock stopped, a brass guillotine door, 30.5 cm from the end of the runway, was manually lowered to prevent retracing. Two identical food cups were constructed by drilling two

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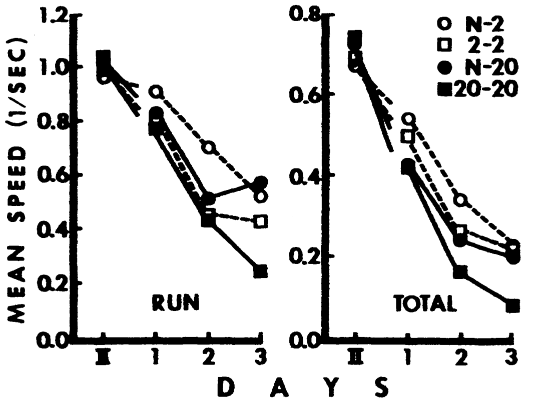

Fig. 1. Mean extinction speeds in the run section and the total alley for the two initial nonreward groups and the two CRF control groups on the last day of Phase 2 (II) and the 3 days of extinction.

3-cm-diam holes in a 5 x 20 x 3.5 cm block of wood. One food cup was always positioned in the center of the goalbox, while the other was not visible to S. The left cup was used for all rewarded and the right cup for all nonrewarded trials on the first day of training. These conditions were then reversed on the second day, and so on.

Procedure

The Ss were placed in individual cages upon arrival at the laboratory. After 14 days of free access to food and water, the feeding schedule maintained throughout the investigation and consisting of 12 g/day of Wayne Lab Blox with ad lib water in the home cage was begun. The Ss were handled in groups of two for 90 sec/group on Days 8-13 of the deprivation schedule. After being handled on Days 11-13, each S received 10 .045-g Noyes Pellets in a glass dish placed in the home cage. On Day 14, 10 Ss were randomly assigned to each of four groups and training began with each S receiving four trials/day for 5 days each in Phase 1 and Phase 2 of acquisition, followed by five trials on each of 3 extinction days. The Ss were run in two squads of 20 composed of five Ss from each group (intertrial interval = about 20 min). A running order was determined randomly at the start of each day for Ss within subsquads consisting of one S from each group. The 20 Ss in each squad were fed their daily ration minus the amount received in the alley 20 min after the last S in that squad received its last trial for the day.

The Ss were removed from the goalbox immediately upon having consumed all of the reinforcement or after 20 sec on nonrewarded trials. A maximum criterion time (60 sec in Phase 1 and 40 sec in extinction) was allowed in each section of the alley. If an animal exceeded the criterion time in any one section, this additional time was subtracted from the criterion time allowed in the next section forward and added to the latency score of that section. When an animal refused to approach the foodcup within the criterion time, it was gently guided to the goalbox and confined for the usual 20 sec.

The experimental groups composed a 2 by 2 factorial employing two reward schedules in Phase 1 (nonreward, N; or CRF) and two reward magnitudes in Phase 2 (2 or 20 pellets). The four groups, designated by Phase 1 and Phase 2 reinforcement conditions, respectively, were N-2, N-20, 2-2, and 20-20.

RESULTS

The times from each alley section were added together to produce a total time, and all times were converted to speeds (1/sec). A 2 by 2 analysis of variance, with Phase 1 reward schedule (schedule) and Phase 2 reward magnitude (magnitude) as between-S factors and trials as a within-S factor, was applied to speeds in each alley section on the last day of Phases 1 and 2. The extinction analysis included trials and days as within-S factors. In extinction, the effects of schedule were most apparent in run and the effects of magnitude were largest in total. As most effects were not significant in start, and goal speeds resembled total speeds, only run and total speeds are reported for Phase 1, Phase 2, and extinction.

Phase 1

In Phase 1, Group N-2 did not differ from Group N-20 and neither group showed any appreciable increase in speed over days. At the end of Phase 1, Group 20-20 was responding faster than Group 2-2, which in turn, of course, was considerably faster than the initial nonreward groups. On the last day of Phase 1, differences due to schedule were significant ($F = 141.27$ in run and $F = 272.64$ in total, $df = 1/36$, $p < .001$), as were differences due to magnitude ($F = 7.63$ in run and $F = 9.98$ in total, $df = 1/36$, $p < .01$). However, differences due to magnitude occurred only for the CRF groups, as magnitude was a "dummy" variable for the initial nonreward groups. Thus, schedule interacted significantly with magnitude ($F = 4.51$ in run and $F = 7.52$ in total, $df = 1/36$, $p < .05$).

Phase 2

In Phase 2, differences between Groups 2-2 and 20-20 decreased over days and Groups N-2 and N-20 rapidly reached the speeds attained by the CRF groups. By the last day of Phase 2, there were no differences due to either schedule ($Fs < 1$) or magnitude ($F = 2.58$ in run and $F = 3.53$ in total, $df = 1/36$), nor was there a Schedule by Magnitude interaction ($Fs < 1$). Thus, all groups had attained approximately the same level of responding by the end of Phase 2.

Extinction

Figure 1 shows the mean run and total speeds for each of the experimental groups on the last day of Phase 2 and each day of extinction. In the run section, the two groups given initial nonrewards were more resistant to extinction than the two CRF groups. Differences between the two initial nonreward groups in run appear small, as do differences between the two CRF groups. In total, on the other hand, resistance to extinction was increased both by initial nonrewards in Phase 1 and small rewards in Phase 2. These observations were supported by a significant effect of schedule in run ($F = 6.5$, $df = 1/36$, $p < .01$) and a significant effect of magnitude in total ($F = 7.4$, $df = 1/36$, $p < .01$). The schedule effect in total, however, only approached a conventional level of significance ($F = 2.94$, $df = 1/36$,

$.05 < p < .10$). There was no effect of magnitude in run ($F = 1.46$, $df = 1/36$) and there was no Schedule by Magnitude interaction in run or total ($Fs < 1$). As can be seen in Fig. 1, the INE in the run section was largest for Group N-2 on Day 2 of extinction and largest for Group N-20 on Day 3 of extinction. This difference contributed to a significant Schedule by Magnitude by Days interaction in run ($F = 5.97$, $df = 2/72$, $p < .01$) and planned comparisons performed on these data showed that the difference between Groups N-2 and 2-2 was significant on Day 2 ($F = 6.1$, $df = 1/36$, $p < .05$) and the difference between Groups N-20 and 20-20 was significant on Day 3 ($F = 11.78$, $df = 1/36$, $p < .01$).

DISCUSSION

In the run section, Ss given initial nonrewards were more resistant to extinction than Ss given CRF alone, while in total R to E was decreased by large reward in Phase 2. There was no effect of reward magnitude on the size of the INE in run or total, the INE appearing to be as large with 2 as with 20 pellets. The present results are in agreement with those of previous investigations in showing that R to E is increased by initial nonrewards (Robbins et al, 1968; Spear et al, 1965; Spear & Spitzner, 1967). In addition, the usual inverse relationship which obtains between magnitude of CRF and R to E was reproduced here; but, unlike the direct relationship between magnitude of PRF and R to E, initial nonreward produced an inverse relationship between magnitude of reward and R to E. Hence, while the PREE is larger with large reward than with small, reward magnitude did not differentially affect the size of the INE.

One way to account for the INE would be to assume that the stimuli which regulate extinction are more strongly conditioned under initial nonreward-CRF training than under CRF training alone. This might occur if, say, Ss acquired an expectancy of nonreward during the initial nonreward phase and, as suggested by Capaldi (in press), conditioning was stronger the greater the discrepancy between expected and obtained reward. According to this view, initial nonrewards would decrease expectancy and, hence, would increase the strength of conditioning during the subsequent CRF phase relative to conditioning under CRF alone, thereby producing an INE.

The effects of reward magnitude on the INE can be explained by combining the above account of the INE with a sequential analysis of CRF reward magnitude effects (e.g., Capaldi, 1967). The theoretical picture following acquisition under CRF is shown in Fig. 2a.

The abscissa represents a continuum of stimulus similarity along which internal stimuli produced by large reward (S^L), small reward (S^S), and nonreward (S^N) may be ordered. Arbitrary units of habit strength (H) accrued to S^L and S^S are represented by vertical lines. According to the sequential model (Capaldi, 1967), R to E is governed by the amount of H present at S^N. As can be seen in Fig. 2a, S^S would supply more generalized H to S^N than would S^L because of the relative distances of these stimuli from S^N. Hence, R to E would be greater after training with small CRF than with large CRF, as obtained in the present experiment.

Initial nonreward training, it was suggested above, increased R to E by increasing the strength of conditioning. As shown in Fig. 2b, then, S^L and S^S would acquire increased H under initial nonreward-CRF training and would supply more generalized H to S^N during extinction than under CRF training alone. Hence initial nonreward training would produce an INE whether reward magnitude was large or small. As can be seen by comparing the theoretical situation in Figs. 2a and 2b, initial nonrewards would elevate R to E about as much under small reward as under large reward.

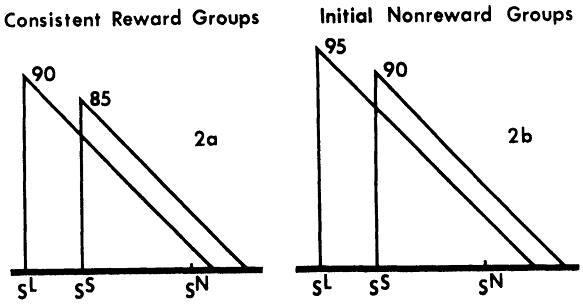

Fig. 2. Theoretical curves for CRF and initial nonreward groups. The left panel shows units of habit strength (vertical lines) and generalization of habit from S^L and S^S to S^N following CRF acquisition. The right panel shows habit strength and generalization of habit following initial nonreward-CRF training.

Given the present suggestion that the level of conditioning reached in Phase 2 was increased by initial nonrewards, initial nonreward groups might have been expected to run more rapidly than their CRF controls, i.e., a positive contrast effect (PCE) would be expected to have occurred in Phase 2. A PCE was not obtained in the present investigation. However, in the Robbins et al (1968) investigation, the initial nonreward group showed a sizable PCE.

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