

Independent effects of percentage of partial reward on resistance to extinction

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Rats were trained in the straight runway under different percentages of partial reward and then extinguished. Within-day nonreward-reward and reward-nonreward transitions were held constant during acquisition. The data showed that small percentage of partial reward led to greater resistance to extinction than did large percentage. The results were interpreted as supporting Amsel's frustration hypothesis.

In support of Capaldi's (1967) sequential hypothesis of instrumental learning, two experiments, which factorially combined different sequences and percentages of partial reward, demonstrated a significant effect on resistance to extinction of sequence but not percentage of reward. Spivey (1967) found resistance to extinction to be a positive function of number of nonreward-reward transitions during acquisition; Gonzalez & Bitterman (1964) found that resistance to extinction was increased by longer chains of successive nonrewards during acquisition. However, in both experiments, smaller percentages of reward led to greater resistance than did larger percentages, although the differences were not statistically significant. Perhaps the reliability of a phenomenon as demonstrated by replication is of equal importance as estimates of reliability obtained by statistical analysis of the results of a single experiment.

The purpose of this investigation was to conduct additional experiments on the effects of varying percentage of partial reward on resistance to extinction. In this case, sequence of partial reward was controlled.

EXPERIMENT I

In Experiment I, rats were trained in the straight runway with two different percentages of reward. The design yielded equal numbers of within-day nonreward-reward and reward-nonreward transitions under the two conditions. However, between-day transitions varied with percentage.

The rationale of the design was that sequential effects are assumed to be specific to the intertrial interval (ITI) in which they occur (Capaldi, 1967; Leonard, Albin, & Lebowitz, 1969). Since between-day acquisition transitions varied but within-day

transitions were held constant, the sequential hypothesis predicts differential resistance to extinction for groups extinguished with the between-day ITI, but no difference between groups extinguished with the within-day ITI.

Subjects

The Ss were 42 naive male albino rats, weighing 250-300 g, purchased from the Holtzman Co., Madison, Wis.

Apparatus

The apparatus was a gray wooden straight runway, 60 in. long, 4 in. wide, and 6 in. high, with mesh bottom and Plexiglas top. At the goal end was a sliding food tray mounted behind a gray 2-in.-high wooden barrier. A partition divided the tray into two compartments, and it could be aligned so that only one compartment was accessible.

Infrared photocell units were mounted 6 and 54 in. from the start end of the runway. When the final photobeam was interrupted, an electric brake was released, which allowed a counterweighted 5½-in. section of the Plexiglas roof to swing down, forming a 14-in. goalbox. The brake was automatically reactivated, locking the door in place and confining the S to the goal area. A Standard Electric 1/100-sec clock measured time between placing Ss in the runway through the first photobeam and interruption of the final photobeam.

An exhaust fan was mounted underneath the goal area with intake in the start area. A previous experiment (Phillips & Bloom, 1971) has shown that this apparatus controls between-trial differential odors (cf. McHose & Ludvigson, 1966).

Procedure

On the first 14 days, the Ss were fed Rockland Breeder Diet pellets for 1 h at the approximate time that they were to receive the daily training trials. On Days 13 and 14, they were placed in the goalbox for the first 5 min of the feeding period, with the food tray containing .045-g Noyes pellets.

Following pretraining, Group 67 (21 Ss) received a reward, a nonreward, and a reward (RNR) each day, in that order, for 10 days. Group 50 (21 Ss) received half nonreward-reward-nonreward (NRN) and half RNR sequences in alternating order, beginning with NRN and ending with RNR. Each group was divided into two squads, one of which began training 2 days in advance of the other. The intertrial interval was 20 sec.

On Day 11, 11 Ss from each group were given 15 extinction trials with a 20-sec intertrial interval (Groups 50-S and 67-S). The remaining 10 Ss in each group were extinguished with one trial each day for 15 days (Groups 50-L and 67-L).

Goalbox confinement time was 30 sec on both N and R trials throughout the experiment.

Results

An inspection of the acquisition data showed no evidence of response patterning.

The medians for each S in blocks of three trials during extinction were transformed to Log 10X, and the results are shown in Fig. 1. Analysis of variance showed that Acquisition Group 50 was more resistant to extinction than Acquisition Group 67, in terms of both overall level and rate, as indicated by the significant percent main effect ($F = 7.00$, $df = 1,39$, $p < .05$) and significant Percent by Block interaction ($F = 3.12$, $df = 4,152$, $p < .05$). Other results of interest were that the Percent by Intertrial Interval and Percent by Intertrial Interval by Block interactions were not significant ($F_s < 1$).

An additional analysis showed that Group 50-S was more resistant to extinction than Group 67-S with respect to both level ($F = 4.41$, $df = 1,20$, $p < .05$) and rate ($F = 2.58$, $df = 4,80$, $p < .05$) of extinction.

Discussion

According to Capaldi (1967), previous experiments obtaining differences in extinction as a function of percentage of partial reward are confounded by sequence variables. Lower percentages contain precisely those sequences which should increase resistance. As previously noted, the present experiment used the intertrial interval (ITI) specificity method to separate the effects of sequence and percentage. With regard to the 20-sec ITI, sequence was held constant; Groups 50 and 67 were given equal numbers of nonreward-reward and reward-nonreward transitions. With regard to the 24-h ITI, the 50 schedule produced five nonreward-reward and four reward-nonreward sequences and the 67 schedule produced nine

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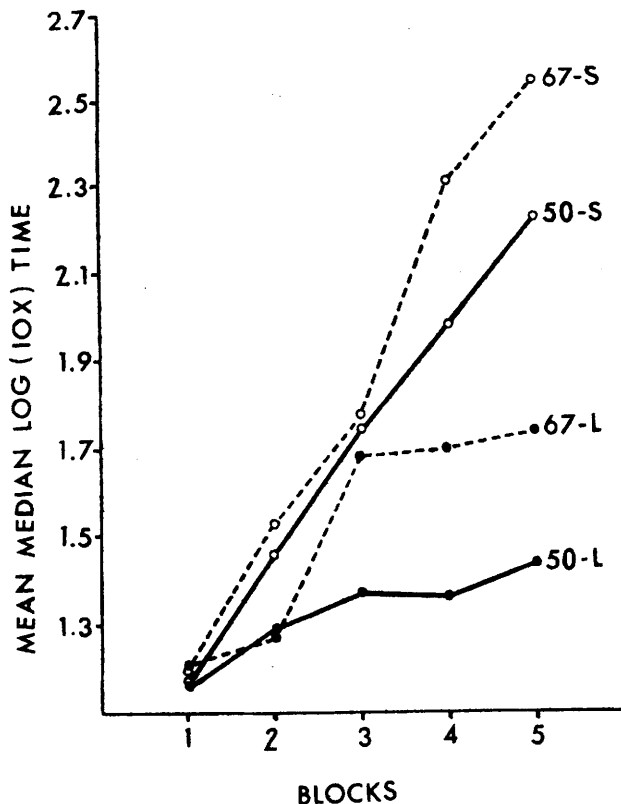


Fig. 1. Extinction responding as a function of percentage of partial reward and intertrial interval.

reward-reward sequences. Thus, groups extinguished under the 20-sec ITI should not differ, but groups extinguished under the 24-h ITI should differ.

In fact, the results indicate that percentage of reward has a significant effect on resistance to extinction, independent of sequence. Groups receiving a smaller percentage of reward during acquisition were more resistant than groups receiving a larger percentage regardless of ITI. The results are consistent with Amsel's (1967) frustration hypothesis, which assumes that conditioned frustrative stimuli support extinction responding. In the present experiment, Group 50 received more nonrewards than did Group 67, allowing more evocations of frustration and therefore stronger conditioning of frustration-produced stimuli to the instrumental response.

It is possible, however, that the sequential hypothesis might account for the results in terms of generalization of between-day sequential effects to within-day responding. The Leonard et al (1969) experiment, which found evidence in support of the ITI specificity assumption, used different within-day transitions, while in the present experiment, within-day transitions were held constant. Experiment II was

conducted in order to test the generalization interpretation.

EXPERIMENT II

In this experiment, the design included two groups in which

within-day transitions and percentage were held constant but between-day transitions varied.

Method

The method was exactly the same as in Experiment I, with the following exceptions: There were 46 Ss, there were 12 days of acquisition, and all Ss were extinguished with the short ITI. Group 50-DA (17 Ss) received half RNR and half NRN acquisition trial sequences in double alternating order over days; Group 50-SA (17 Ss) received the sequences in single alternating order; and Group 67 (12 Ss) was given RNR daily sequences. Thus, between days, Group 50-DA received RR, NN, RN, and NR transitions, Group 50-SA received NR and RN transitions, and Group 67 received only RR transitions.

Results and Discussion

Again, the acquisition data showed no evidence of response patterning. The extinction results are shown in Fig. 2. Analysis of variance showed no significant difference in resistance to extinction between Groups 50-SA and 50-DA with respect to either level or rate of extinction. Further analysis showed that Group 67 was less resistant to extinction with respect to rate ($F = 2.49$, $df = 4, 176$, $p < .05$) but not level ($F = 2.16$, $df = 1, 44$) than Groups 50-SA and 50-DA combined.

While the complexities of Capaldi's (1967) hypothesis makes difficult an accurate directional prediction for the behavior of Groups 50-SA and 50-DA, it seems clear that the differences in between-day transitions during

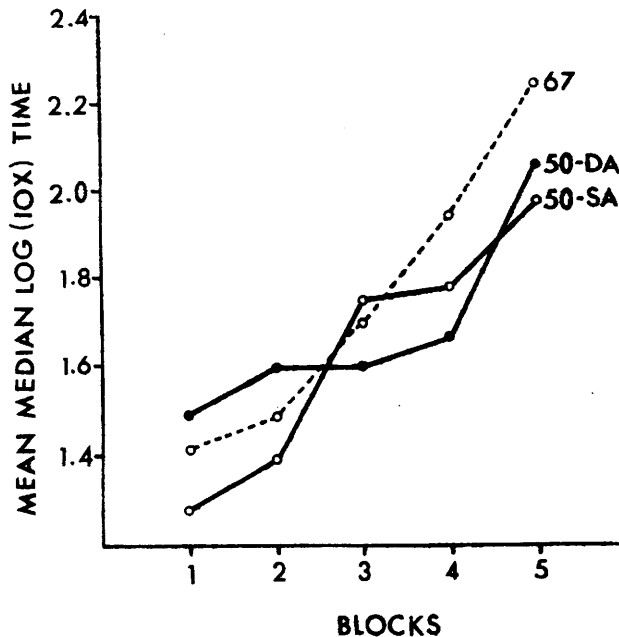


Fig. 2. Extinction responding as a function of percentage of reward and alternation of daily sequence.

acquisition should produce different sequential effects. If these effects generalized to within-day responding during extinction, then differential resistance to extinction should have occurred when these groups were extinguished with the within-day intertrial interval.

Since there was no difference in extinction between Groups 50-SA and 50-DA, it is assumed that generalization cannot account for the results of Experiment I. Also, the smaller percentage schedule was again associated with greater resistance to extinction, which further supports the

reliability of the effect and an interpretation in terms of frustration theory.

REFERENCES

- AMSEL, A. Partial reinforcement effects on vigor and persistence. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation*. Vol. 1. New York: Academic Press, 1967.
- CAPALDI, E. J. A sequential hypothesis of instrumental learning. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation*. Vol. 1. New York: Academic Press, 1967.
- GONZALEZ, R. C., & BITTERMAN, M. E. Resistance to extinction in the rat as a function of percentage and distribution of reinforcement. *Journal of Comparative & Physiological Psychology*, 1964, 58, 258-263.
- LEONARD, D. W., ALBIN, R., & LEBOWITZ, M. Performance under massed or spaced extinction following different sequences of varied reward training. *Psychonomic Science*, 1969, 16, 130-132.
- McHOSE, J. H., & LUDVIGSON, H. W. Differential conditioning with nondifferential reinforcement. *Psychonomic Science*, 1966, 6, 485-486.
- PHILLIPS, J. M., & BLOOM, J. M. Control of conspecific odors in the runway. *Psychological Reports*, 1971, 29, 838.
- SPIVEY, J. E. Resistance to extinction as a function of N-R transitions and percentage of reinforcement. *Journal of Experimental Psychology*, 1967, 75, 43-48.