Some effects of reward schedule and confinement duration upon patterning and resistance to extinction in the rat*

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Forty-four rats were used to study the effects of reward schedule (partial reward vs partial delay of reward) and duration of delay-box confinement (0 sec vs 60 sec) on runway acquisition and extinction. Three trials per day were given in a RXR order where the R was an immediate reward trial and the X was either nonreward (PR groups) or delayed reward (PD groups). The appropriate confinement was imposed on the X trial for both the PR and PD groups. Patterned running (slow speeds on the X trial and fast speeds on the R trials) developed during acquisition and continued during extinction. Patterned running was a function of both schedule (with PR running slower on the X trial than PD) and confinement (with long confinements resulting in slower speeds on the X trial). Resistance to extinction was greater for PR than for PD, and delay-box confinement increased resistance to extinction in PD but decreased resistance to extinction in PR. These results were discussed in terms of current theories of resistance to extinction.

Since Crum, Brown, & Bitterman (1951) first reported extinction similarities between partial reward (PR) and partial delay (PD) schedules of reward, there has been considerable theoretical interest in predicting the extinction behavior produced by these two schedules from a single set of theoretical principles. Three of the most viable and recent theories of extinction performance (Amsel, 1962; Capaldi, 1967; Lawrence & Festinger, 1962) can be shown to predict that the resistance to extinction (R to E) of PR and PD schedules results from similar variables. Specifically they predict that PR should be more resistant than PD and both more than CRF, and that increasing the duration of delay should increase R to E. Despite these singular predictions, there have been relatively few direct comparisons of PR schedules with PD schedules (exceptions are by Peterson, 1956; Cogan & Capaldi, 1961; Burt & Wike, 1963; and Capaldi & Oliver, 1966), and when such comparisons have occurred, they have not always been in agreement (compare Cogan & Capaldi, 1961, with Burt & Wike, 1963), nor have they always confirmed the above predictions (Burt & Wike, 1963). For example, Burt and

Wike compared PR to PD in a 10-trials-per-day single-alternation schedule. The PD groups were confined in the goalbox on D trials for 20, 60, or 100 sec prior to 20 sec of reward. The PR groups were confined in the goalbox on N trials for 20, 80, or 120 sec prior to removal from the goalbox. A separate PR control group of four rats was run with 40-sec confinement in the goalbox to match the total confinement time of the PD 20-sec group. Burt and Wike reported that patterned running developed in acquisition, i.e., slow running on N or D trials and fast running on R trials, and that patterning was a function of confinement, i.e., the longer confinements patterned better than the shorter confinements. In extinction, the PR groups were faster than the PD groups, but there was no effect attributable to confinement duration. This study provided partial support for each of the above theories in that PR showed greater R to E than PD, although the failure to include a CRF control leaves in doubt whether or not either sequence had increased R to E. The failure to find a duration effect in extinction, however, is

Fig. 1. Mean median run speeds in blocks of 3 days during acquisition.

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unexpected, since the duration differences must have been great enough to produce differential frustration (Amsel, 1962), dissonance (Lawrence & Festinger, 1961), and aftereffects (Capaldi, 1967), as those differences were large enough to produce differential patterning. Thus effects large enough to produce acquisition differences were not sufficient to produce the expected extinction differences. Before revising the theories, several precautions suggest that the Burt and Wike study should be extended. First, the missing CRF control causes us to wonder if the typical PD effect was present at all, i.e., the usual PD effect can be interpreted as a duration difference. Second, the use of goalbox delay means that all groups were spending a certain amount of time in the goalbox, but without reward. If both the PR and PD groups receive nonrewarded goalbox time, similarities in the two schedules can be easily understood. Since nonrewarded goalbox time is required in PR but not in PD schedules, one solution is to impose the delay confinement in a separate delay box. The purpose of this study was to test the effect of increasing confinement duration of PR and PD schedules with a CRF control included and using the separate delay-box procedure.

DESIGN

The basic design was a 2 by 2 completely randomized factorial with two reward schedules (PR vs PD) and two confinement durations (0 sec and 60 sec).

SUBJECTS

The animals were 44 naive male Sprague-Dawley rats obtained from Holtzman Co., Madison, Wis. The rats were approximately 75 days old at the start of pretraining and were equally distributed among the four cells of the basic design. One rat was discarded in acquisition due to illness.

APPARATUS

The apparatus was a 2.59-m runway with three automatic guillotine-type doors. These doors served to separate the 25.6-cm L-shaped delay box from the 30.8-cm goalbox. All sections were gray, except for the white delay box, and the entire runway was covered by hinged .64-cm hardware cloth tops.

Three Standard clocks, calibrated to .01 sec and controlled through three Hunter photorelay units, measured start and run times.

PROCEDURE

Upon receipt from the supplier, the rats were housed individually and placed on 2 weeks' ad lib access to food and water. Each rat was then reduced to 85% ad lib weight and maintained at that weight throughout the study. Pretraining consisted of 4

Fig. 2. Mean median run speeds during extinction.

days of exploration trials in which the rats were allowed to move freely throughout the runway, first in groups of four, then two, and then individually. On the last 3 days of pretraining, the solenoids, which would later operate the doors, were activated several times to adapt the animals to the loud noises. Throughout pretraining, unlimited access to .045-g Noyes pellets (to be used as reward) was allowed in the goalbox. By the fourth day, all of the rats were eating freely and did not appear to be startled by the apparatus noises.

ACQUISITION

For 27 days of acquisition, each rat was given three daily trials with an intertrial interval of 30 sec. The first and third trials for all groups were immediately rewarded with two pellets. The four groups differed only on the second daily trial. For two of the groups, no reward was present in the goalbox on that trial (PR groups). For the remaining two groups, 10 pellets were presented (PD groups). One-half of the animals from both PR and PD schedules received 0-sec delay chamber confinement on the second trial, and the remaining one-half received 60-sec confinement on the second daily trial. All trials involved a 30-sec confinement in the goalbox.

The rats were run in squads of eight, with two animals from each cell represented. The order of running the squads was randomized daily. Approximately 15 min after the last rat was run, each rat was weighed and fed an amount necessary to maintain its 85% ad lib weight.

EXTINCTION

For 9 days of extinction, the acquisition conditions were continued, with the following exceptions: (1) reward was discontinued, and (2) delay chamber confinement was

discontinued, i.e., all trials for all groups were 0-sec confinement in the delay chamber. The three trials per day, the 30-sec intertrial interval, and the 30-sec goalbox confinement were continued.

RESULTS

Start and run times were recorded in .01-sec units and converted into speed scores (100/time). Since the analysis of the start and run times were in very close agreement, only the run times will be presented here.

Acquisition

Median run speeds of the nine blocks of 3 days were taken separately for each daily trial and are shown in Fig. 1. It would appear that the two longer confinement groups had patterned better than the shorter confinements and that PR patterned better than PD in those groups in which patterning developed. A 2 by 2 by 3 by 9 mixed analysis of variance with schedule (PR vs PD), confinement (0 sec vs 60 sec), pattern (Daily Trial 1 vs 2 vs 3), and blocks (the nine blocks of 3 days) was run. The following effects were found to be significant ($p < .05$): (1) confinement ($F = 8.63$, $df = 1/40$), (2) Confinement by Schedule ($F = 6.11$, $df = 1/40$), (3) pattern ($F = 97.91$, $df = 2/80$), (4) Schedule by Pattern ($F = 27.10$, $df = 2/80$), (5) Confinement by Pattern ($F = 114.50$, $df = 2/80$), (6) Schedule by Confinement by Pattern ($F = 13.13$, $df = 2/80$), (7) blocks ($F = 194.02$, $df = 8/320$), (8) Schedule by Confinement by Blocks ($F = 9.24$, $df = 8/320$), (9) Confinement by Blocks ($F = 57.92$, $df = 16/640$), (10) Schedule by Pattern by Blocks ($F = 8.32$, $df = 16/640$), and (11) Confinement by Pattern by Blocks ($F = 37.97$, $df = 16/640$).

The major findings in acquisition were: (1) patterned running developed with slower running on Trial 2,

(2) patterning was a function of schedule with the PR groups running more slowly on Trial 2 than did the PD groups, and (3) patterning was a function of confinement with the 60-sec groups running more slowly on Trial 2.

Extinction

The occurrence of large terminal acquisition differences suggests the advisability of equating extinction performance on the basis of acquisition differences. However, since acquisition differences were found mainly on Trial 2 and Anderson (1963) curves are not appropriate, the remaining alternative is to examine the simple main effect tests to determine which effects were significant independent of the second daily trial.

The run speeds for the 9 days of extinction are shown in Fig. 2. It may be seen that Trial 2 acquisition differences continued in extinction. It would further appear that, on Trial 3, the CRF or PD 0 group extinguished fastest, the PD 60 and PR 60 groups were about the same, and the PR 0 group extinguished most slowly. These suggestions were confirmed by the statistical analysis. A 2 by 2 by 3 by 9 mixed analysis of variance was performed on the extinction run speeds. The following significant ($p < .05$) effects were found: (1) schedule ($F = 10.14$, $df = 1/40$), (2) confinement ($F = 7.08$, $df = 1/40$), (3) Schedule by Confinement ($F = 17.84$, $df = 2/80$), (4) Confinement by Pattern ($F = 25.42$, $df = 2/80$), (5) Schedule by Confinement by Pattern ($F = 6.91$, $df = 2/80$), (6) blocks ($F = 159.82$, $df = 8/320$), Schedule by Blocks ($F = 6.14$, $df = 8/320$), Schedule by Confinement by Blocks ($F = 7.00$, $df = 8/320$), Pattern by Blocks ($F = 12.38$, $df = 16/640$), and Confinement by Pattern by Blocks ($F = 9.36$, $df = 16.64$).

Examination of Trial 3, where acquisition differences had not been significant, indicated that PR extinguished more slowly than PD ($F = 26.47$, $df = 1/40$). Examination of the Schedule by Confinement interaction on Trial 3 indicated that the schedule effect occurred mainly at the 0-sec confinement ($F = 42.21$, $df = 1/40$), with PR 0 faster than PD 0, and not at all at the 60-sec confinement ($F < 1$).

Further examination of Trial 3 indicated a disordinate Confinement by Schedule interaction, i.e., increased confinement decreased speeds for the PR schedule ($F = 10.70$, $df = 1/40$) and increased speeds for the PD schedule ($F = 9.24$, $df = 1/40$). Thus,

on the third daily trial, the groups were ordered in the following manner: PR 0 > PR 60 = PD 60 > PD 0.

DISCUSSION

The results of the present study are in close agreement with the results of Burt & Wike (1963) in that: (1) acquisition patterning was a direct function of confinement duration, (2) acquisition patterning was a function of schedule, with PR patterning better than PD, and (3) R to E was a function of schedule, with PR more resistant than PD. Unlike the Burt and Wike study, this experiment showed an extinction interaction on Trial 3 between schedule and confinement duration, with confinement resulting in increased R to E in PD but decreased R to E in PR. It is not clear that the previous failures to uncover an extinction effect for acquisition confinement may be explained by a comparable reversal of the effects of confinement.

The results of the present study provide partial support for current theories regarding R to E (e.g., Amsel, 1962; Capaldi, 1967; Lawrence & Festinger, 1962) in that they each predict that PR and PD both increase R to E and PR more than PD. This study provides only partial support for the theories in that, while none specifically predict the effect of increased delay-box confinement on the PR groups, they certainly do not predict the decreased R to E found. It should be noted that the long-standing discrimination hypothesis, recently formulated in the context of Capaldi's sequential trial theory by Campbell, Crumbaugh, Rhodus, & Knouse (1971) would suggest that the presence of patterning based upon a given manipulation (in this case, confinement duration) may eliminate or reverse the extinction effect of that manipulation. This hypothesis is capable of explaining the decreased R to E in the PR groups but does not seem to explain the increased R to E of the PD groups where acquisition patterning was also present.

Quite apart from the extinction results, perhaps our most remarkable finding was that patterning occurred at all. Patterning has been reported in single alternation sequences but not in double alternation sequences (Bloom & Capaldi, 1961) or the present RRR sequence. Even more impressive was the finding that patterning continued in extinction.¹ Trial 2 speeds remained slow in extinction, whereas Trial 1 and Trial 3 speeds followed the normal course of extinction. This is a strong indication that patterning was based somewhat upon cues associated with a

given daily trial rather than just upon the aftereffects of the preceding trial. In extinction, the aftereffect of nonreward (or delayed reward) had been followed by a rewarded trial. Had patterning been based upon aftereffects alone, extinction should have produced uniformly fast speeds within the PR and PD groups. One possible method to emphasize the relative control of the goalbox aftereffects over patterned running would have been to mass the extinction trials.

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NOTE

1. We are quite confident about these findings, since an unpublished experiment from our laboratory has replicated the occurrence of patterning in both acquisition and extinction. In that experiment, an RRR schedule was used and PR vs PD was factorial with four confinement durations (0, 15, 30, and 60 sec). The results of that experiment supported the findings of the present experiment in detail. One exception was that no extinction effects could be attributed to confinement in our unpublished study.