

interpretation is supported by the tendency of several of the Ss in both Group F/AS and Group F/AMN to leave up to 50% of the pellets they received uneaten.

Suppression of water-reinforced responding was not found for either Groups W/AS or W/AMN, a result which is in accord with previous work (Stein, 1963) showing no significant suppression of water intake with a dose of 2.5 mg/kg atropine, although there was a significant suppression with a dose of 5 mg/kg. Thus, the effects of atropine on thirst-related behavior would appear to be dose-dependent. It is quite likely that the degree of suppression is not a simple function of the degree of cholinergic attenuation in the central nervous system, but rather a complex function of that attenuation in relation to the amount of anticholinergically induced peripheral feedback. At low dose levels, the peripheral feedback should induce sufficient activity in the central structures involved in thirst-related behavior so as to counteract the partial inhibition of those structures. As the dose level increases, the degree of central attenuation should become great enough so that the peripheral feedback should have minimal effect, and thirst-related behavior should show maximal suppression.

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established phenomenon with single alternating partial reinforcement (Capaldi, 1967). Within the area of partially delayed reward, Cogan and Capaldi (1961) reported a failure to find pattern running when a 20-sec delay occurred in the goal box. Burt & Wike (1963) replicated the Cogan and Capaldi findings but reported pattern running when delays were extended to 60 and 100 sec.

The purposes of the present study were: (1) to determine if pattern running would occur at 20-sec delays if the delay occurred in a separate distinctive delay chamber, (2) to assess the effects of D-I transitions at long and short intertrial intervals, and (3) to determine the effects of sequence of confinement in extinction.

#### METHOD

Forty naive female albino rats, approximately 120 days old, were maintained on a 23-h food-deprivation schedule. Ss were adjusted to the deprivation schedule, handled, and tamed during the first 10 days of the experiment.

The apparatus, a 5-ft 3-in. L-shaped runway was painted flat black and covered with a hardware cloth top, with the exception of an unpainted, Plexiglas-covered delay chamber that separated the run and goal sections. Response times were recorded in .01-sec units for three 1-ft sections of the runway by means of a system of photo relays and Hunter Klockounters.

Following 4 days of runway exploration, all Ss were given two trials without delay to a standard reward of two .097-g Noyes pellets. After the above pretraining, 20 Ss were randomly assigned to either D-I or I-D acquisition sequences and given two trials/day for 16 days. Following acquisition, each original group was divided into four equal subgroups and given 8 days of extinction training at two trials a day. During extinction, Ss were confined in the delay chamber (prior to entering the empty goal box), according to one of the following daily sequences: D-D, D-I, I-D, or I-I. The design then was a 2 by 4 factorial with two levels of trial sequence in acquisition and four levels of trial sequence in extinction. Delay and goal box confinement times were 20 sec during both acquisition and extinction. Trials were rotated among Ss in squads of eight with one S from each cell represented. The squads were run in a random order each day and fed daily at least 20 min after the completion of training. The intertrial interval (ITI) averaged approximately 7 min during acquisition but gradually increased to approximately 20 min during extinction.

#### RESULTS

Response times for the third measure (entering the delay chamber) were

## Sequences of delayed reward and extinction confinement: Effects on pattern running and extinction performance<sup>1</sup>

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*Forty rats were trained in a runway under a single-alternation partially delayed reward schedule. The trial sequence was either D-I or I-D during training and D-D, D-I, I-D, or I-I during extinction. During training, the Ss learned to run rapidly on I trials and slowly on D trials. During extinction the D-I training sequence resulted in greater resistance to extinction than I-D, but only on the second daily trial. The extinction speeds were also inversely related to percentage of delay confinement in extinction.*

According to Capaldi's (1967) sequential-trial theory, one major determinant of instrumental performance is the sequence of reward outcomes from trial

to trial. Within partially delayed reward schedules, for example, Wike, Kintsch, & Gutekunst (1959) have shown that schedules containing transitions from delayed to immediate reward (D-I transitions) produce greater resistance to extinction than schedules containing only I-D transitions. Capaldi & Poynor (1966) found a similar effect when I trials followed long as opposed to short delayed trials. Further, Wike, Platt, & Parker (1965) found this same sequence effect when blocks of D trials were followed by blocks of I trials.

An additional consequence of acquisition-trial sequence is referred to as pattern running. Pattern running results when trials with different incentive values occur in a predictable sequence. Animal Ss learn to run rapidly on trials with large incentive and slowly on trials with little incentive. Pattern running is a well

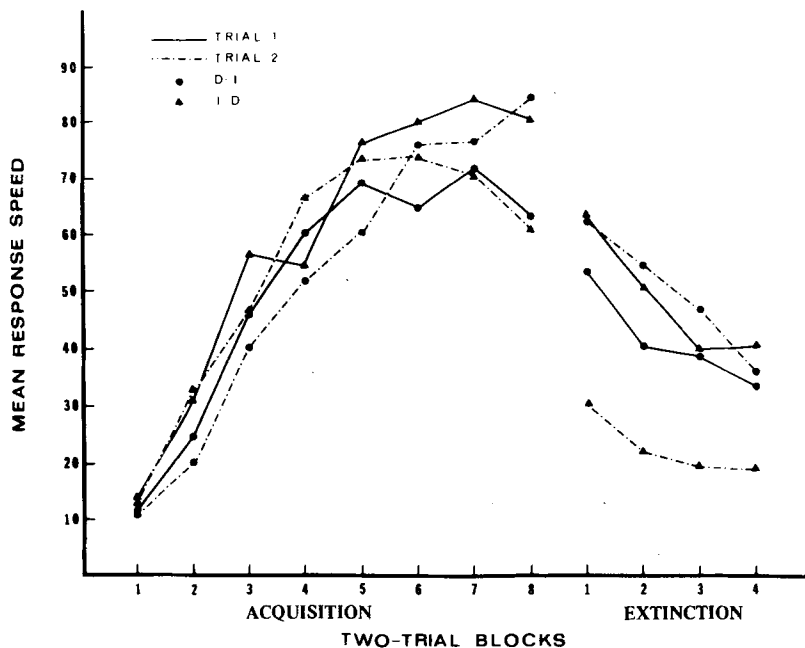


Fig. 1. Mean acquisition and extinction speeds for each acquisition sequence on each daily trial.

groups to begin extinction at speeds that would help confirm the sequential transition expectations. A rate correction (Anderson, 1963) was not used since the data did not meet the necessary assumptions. Furthermore, only the I-D Ss continued to pattern in extinction, which would make an explanation based on the simple continuation of acquisition performance less tenable.

The observed effect of extinction delay box confinement on extinction performance is in agreement with the findings of Wike, Mellgren, & Wike (1968) that running speed in extinction is inversely related to the percentage of delay box confinement in extinction.

converted to speed scores (100/sec). Figure 1 presents Trial 1 (T1) and Trial 2 (T2) speeds for the acquisition sequence variable for both acquisition and extinction data. The extinction data are collapsed across the four extinction confinement sequences.

An analysis of variance on the last block of acquisition trials confirmed the suggestion in Fig. 1 that both groups showed reliable pattern running. Pattern was highly significant ( $F = 13.96$ ,  $df = 1/38$ ,  $p < .001$ ) and a nonsignificant interaction ( $F < 1.0$ ) suggested that both groups learned the pattern equally well.

Analysis of variance on the extinction data<sup>2</sup> revealed several significant effects: confinement sequence in extinction ( $F = 5.65$ ,  $df = 3/24$ ,  $p < .01$ ), T1 vs T2 ( $F = 12.52$ ,  $df = 1/24$ ,  $p < .001$ ), trial blocks ( $F = 12.29$ ,  $df = 3/72$ ,  $p < .001$ ), and acquisition sequence by daily trial ( $F = 47.82$ ,  $df = 1/24$ ,  $p < .001$ ). An inspection of Fig. 1 suggests the nature of the above interaction. The I-D Ss show slightly more resistance to extinction than D-I Ss at T1, but the opposite result was quite apparent at T2. Simple main effects using the compromise error term suggested by Winer (1962) confirmed these suggestions. D-I vs I-D was highly significant at T2 ( $F = 15.24$ ,  $df = 1/24$ ,  $p < .001$ ), but nonsignificant at T1 ( $F < 1.0$ ). Furthermore, I-D Ss continued to pattern in extinction ( $F = 13.47$ ,  $df = 1/24$ ,  $p < .001$ ) and D-I Ss did not ( $F = 1.42$ ). The extinction confinement main effect (not shown) was due to D-D showing very rapid extinction, I-I Ss extinguished much more

slowly, and D-I and I-D Ss showed intermediate speeds.

#### DISCUSSION

These results suggest that pattern running can occur with delays as short as 20 sec. The discrepancy between these data and those of Cogan & Capaldi (1961) and Burt & Wike (1963) could be due to at least three factors. First, these results occurred with delay occurring in a separate distinctive chamber as opposed to goal box delay. Second, the reward magnitudes from the three studies cannot be compared, i.e., 20-sec access to wet mash as opposed to .097-g pellets. Campbell (1968) has shown that reward magnitude on both D and I trials is an important determinant of patterning. Third, only two daily trials were run here, while both of the other experiments employed 10 trials/day. The possibility, however, that the present patterning was simply due to the tendency to run faster on the first or second daily trial is discounted by the presence of patterning in both the D-I and I-D sequences. The question of which of the above factors is responsible for the discrepancy cannot, of course, be answered from the present design.

The results from the extinction phase agree with earlier research that D-I transitions are important in increasing resistance to extinction. This was true, however, only on T2. Delay to immediate transitions that occurred at 24-h ITI did not cause I-D Ss to show greater resistance to extinction at T1 even though the data were in that direction. These extinction conclusions must be tempered by the fact that acquisition patterning caused these

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#### NOTES

1. This research was partially supported by Grant No. 8469 from Southern Methodist University and the National Science Foundation, and by Grant No. 5T1 NB-5362-05 from the National Institute of Neurological Disease and Blindness to the Bureau of Child Research, Lawrence, Kansas. The study was conducted according to the APA statement of "Principles for the care and use of animals," June 26, 1968.

2. Three Ss from different cells died during extinction. To compensate for unequal cell frequencies, one S, chosen randomly, was discarded from the remaining cells.