Runway performance maintained by multiple rewards per trial

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Thirty-six water-deprived albino rats were trained to traverse an alley that terminated in a goalbox equipped with a liquid dipper. The Ss were assigned to one of four groups produced by the factorial combination of a number of dipper presentations as reward per trial (2 vs 10) and interval between rewards (4 vs 10 sec). Running speed was related negatively to both interreward interval and number of rewards per trial, although the effect was not reliable in the latter case. These results are discussed in terms of a "two-process" interpretation of reinforcement in instrumental conditioning.

In instrumental appetitive conditioning, the strength of the instrumental R typically increases when that R is closely followed by reward (Pobols, 1960). Thus, it is widely accepted that the strength of the instrumental R is a direct function of the quantity or quality of the reward. Nevertheless, a number of Es have described circumstances under which a nominally "small" reward resulted in better instrumental performance than a nominally "larger" reward. For example, Black & Elstad (1964) reported that hungry rats ran faster on a runway to a reward consisting of 10-sec access to wet mash than Ss given 30-sec access. They also reported that, although Ss in the 30-sec group consume more food, Ss in the 10-sec group ate at a higher rate (i.e., they ate more consistently). Similar results have been found by Hiers (1968), Cammin (1968), and Cilluffo (1969).

Black (1969) has proposed an interpretation of the preceding results according to which the Rs S makes in the goalbox (GB) tend to become conditioned to GB and generalize to earlier segments of the runway where their occurrence may or may not interfere with the instrumental (locomotor) R. If the only Rs S makes in the goalbox are consummatory Rs, then only such R tendencies will generalize to the runway. Overt consummatory acts, however, will presumably not occur in the runway, since no food is present. Thus, little interference with the locomotor R is expected. However, if S makes

nonconsummatory Rs in the GB, these Rs will also generalize to the runway where they can occur and interfere with forward locomotion. Thus, one (but not the sole) effect of reward may be to "encourage" consummatory Rs in the GB and to "discourage" other, nonconsummatory Rs. Nominally "large rewards" that are inconsistently consumed may result in poorer performance than "smaller" rewards that are associated with more consistent consummatory behavior.

The results cited above are, of course, consistent with the current hypothesis that an important determinant of the "reinforcement value" of a given reward is the consistency with which S consumes it. Unfortunately, the consistency of eating and the frequency of nonconsummatory activities are usually under the control of S and only indirectly subject to control from E. In the present experiment, an attempt was made to place the opportunities for consummatory and nonconsummatory responses under more control by E. Specifically, Ss were trained to traverse a straight alley and to enter a GB in which reward was presented on each trial in the form of several discrete presentations of a small dipper filled with water. Consummatory activity (drinking) was only possible during the brief periods that the dipper was presented and both (1) the

number of dipper presentations per trial and (2) the interval between presentations was controlled by E. It was expected that as the length of time S spent in the goalbox in nonconsummatory activity (i.e., dipper empty or not present) increased, the strength of the instrumental response would be depressed.

SUBJECTS

The Ss were 36 albino rats, 90 days old at the beginning of training, from the colony maintained by the Department of Psychology, University of South Carolina.

APPARATUS

The apparatus was a straight alley consisting of a 10-in. startbox, 36-in. runway, and 12-in. GB. The alley was 4 in. wide throughout and was an "intermediate" gray. The startbox and GBs were each separated from the runway by guillotine doors. Opening the start door activated a Hunter KlockCounter that stopped when S interrupted a photo-electric circuit 6 in. prior to the GB, thus providing a measure of "running time."

The reward mechanism was a solenoid-operated dipper that, when the solenoid was activated, descended into a reservoir of liquid located below the floor of the GB. When the signal to the solenoid was terminated, the 0.1-ml filled dipper cup returned to the floor of the GB and 1 in. from its end. The apparatus allowed E to select the number of discrete rewards (i.e., presentations of the filled dipper) per trial as well as the interval between successive rewards within each trial.

Fig. 1. Mean running speeds for the four groups as a function of days of training.

Fig. 2. Daily mean running speeds for Ss trained with two rewards per trial (Groups 1 and 2) and those trained with 10 rewards per trial (Groups 3 and 4).

exposure per trial to the GB (G1: N2, I4) showed best performance, while Ss receiving the greatest exposure (G4: N10, I10) were poorest. The groups that received intermediate lengths of GB confinement (G2: N2, I10, and G3: N10, I4) were also intermediate in running speed.

Figure 2 represents the main effect of "number of rewards per trial (N)"—i.e., the mean running speed of G1 and G2 combined contrasted with that of G3 and G4 combined. Inspection of this figure indicates that Ss that received the smaller N (G1 and G2) ran consistently more rapidly than those Ss that received the larger N (10 rewards per trial).

Figure 3 indicates mean running speed for Ss that received their rewards at the long (10 sec) interreward interval as opposed to Ss that received their rewards at an I of 4 sec. It is apparent from this figure that those Ss that were trained with the shorter I (G1 and G3) ran more rapidly than Ss trained with an I of 10 sec (G2 and G4).

The present experiment was treated as a three-factor design with one within-Ss-on-repeated-measurements variable ("trials") and two between-Ss variables ("I" and "N"). Analysis of variance indicated that the effect of "I" was significant [$F(1,32) = 4.71, p < .05$], confirming the superiority of the 4-sec I groups evident in Fig. 3. On the other hand, the apparent superiority of the smaller ("N" = 2) reward Ss in Fig. 2 was

PROCEDURE

All Ss were maintained in individual cages on a 23-h water-deprivation schedule throughout the experiment. The Ss were handled for 5 min each for 2 days. On the next 2 days, they were allowed 10 min each to explore the runway in pairs. Subsequently, Ss were trained to drink from the dipper. In this phase, Ss received one trial per day for 2 days in which the dipper was prefilled. Thereafter, Ss were divided into four groups of nine Ss designated in terms of the number of rewards per trial (N) and the interval between rewards (I) that they received: G1 (N2, I4); G2 (N2, I10); G3 (N10, I4); and G4 (N10, I10). Thus, G1 received two rewards (dipper presentations) on each trial, and the rewards were presented at a 4-sec interval; G4 received 10 rewards at 10-sec intervals, etc.

On each trial, S was placed in the startbox and the startbox door was immediately opened. When S entered the GB, the GB door was closed and the dipper mechanism activated so as to descend into the water reservoir and return to the GB. Thereafter, the dipper descended and refilled for the number of times and at the intervals preselected by E. The rate of presentation of rewards was not affected if S failed to consume the water available in the previous presentation of the dipper. After the first few trials, however, all Ss consumed all of the water in the time they were allotted. It appeared that about 3 sec

was required to drink 0.1 ml of water, which constituted each reward. After the last reward, the dipper automatically was withdrawn, and S was promptly removed from the GB. Each S was given three trials per day for 12 days, with an intertrial interval of about 15 min.

RESULTS

Running speeds were converted to speed scores (feet/second). Figure 1 represents mean daily running speed for the four groups on each of 12 days of training. Inspection of this figure indicates that performance improved with practice for all groups, while consistent differences between groups also seemed apparent. Thus, Ss experiencing the shortest

Fig. 3. Daily mean running speeds for Ss trained with a 4-sec interreward interval (Groups 1 and 3) vs those trained with a 10-sec interval (Groups 2 and 4).

not confirmed at the conventional level [$F(1,32) = 3.42$, $.05 > p < .10$. The interaction of "I" and "N" did not approach significance [$F(1,32) < 1.00$].

The main effect of "trials" was reliable [$F(11,352) = 16.50$, $p < .001$. Thus, performance improved significantly with practice. In addition, the interaction of "trials" and "I" was reliable [$F(11,352) = 2.00$, $p < .02$. The interaction of "trials" and "N," however, did not prove significant [$F(11,352) < 1.00$].

Informal records of Ss' behavior while in the goalbox were made and suggest that pronounced and consistent differences existed among the groups. Thus, upon entering the goalbox, Ss in 1 (N2, 14) tended to run directly to the dipper cup and rapidly drink the water it contained, thereafter maintaining their orientation toward the reward mechanism for the second or so until the cup was refilled. The Ss in G4 also typically ran to the dipper cup and consumed the water it contained, but seldom remained oriented toward it for the 6 or 7 sec until it was refilled. Rather, they commonly engaged in other, nonconsummatory activities such as running away from the reward mechanism to the retrace door and vigorously manipulating that door with their paws. The frequency of such nonconsummatory responses among Ss in Groups 2 and 3 appeared to be intermediate, while the extremes were provided by Groups 1 and 4.

DISCUSSION

The primary purpose of the present experiment was to investigate the hypothesis that an important determinant of the reinforcement value or effectiveness of a given reward is the extent to which that reward results in the occurrence of consistent consummatory activity and the suppression of other nonconsummatory responses. Of central interest is the finding that Ss that received rewards at the short interval ran faster than Ss in the 10-sec groups, which is, of course, consistent with the present interpretation of reinforcement. Since only about 3 sec were required to drink the water in the dipper, Ss in the 4-sec group had to drink quite consistently in order to consume all of the available reward. Conversely, Ss in the 10-sec groups had about 7 sec, or 70%, of their goalbox confinement time in which to engage in nonconsummatory activities, which could presumably generalize to the runway and startbox and interfere with the instrumental, locomotor response. The Ss in the 10-sec groups were, in fact, observed to engage in a considerable amount of overt motor activity other than drinking and at points distant from the dipper.

while Ss in the 4-sec groups showed little or no overt nonconsummatory activity and tended to retain orientation to the dipper throughout their confinement to the goalbox. There was also a suggestion that Ss ran faster to the smaller total reward per trial (2 rewards) than to the larger (10 rewards), although this result failed statistical confirmation. According to the present analysis, the apparent inferiority of the 10-reward Ss might be attributed to the greater opportunity for nonconsummatory activity with 10 interreward intervals than with 2. Even through 2 rewards had greater "apparent reinforcement value" than 10, however, it might still be argued that 10 pellets resulted in a greater "incentive value," which was obscured by response competition. In short, the failure to obtain a pronounced effect of N may have been the result of the opposed processes of incentive motivation and response competition (Black, 1969).

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Effects of chlordiazepoxide on the acquisition of shuttle avoidance in the rabbit¹

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Rabbits injected with various dosages of chlordiazepoxide showed a decrement in the acquisition of a two-way shuttle-avoidance response. It is suggested that these results are not consistent with the notion that chlordiazepoxide reduces fear.

Earlier research by Chisholm & Moore² showed that chlordiazepoxide (CDP) disrupted performance of a previously acquired shuttle-avoidance task. It was also

shown that CDP did not affect discriminative fear conditioning in a situation where tones were paired with inescapable shock, and the effects were tested when the fear CSs were imposed upon avoidance behavior.

Sachs, Weingarten & Klein (1966) studied the effects of CDP (15 mg/kg) on the acquisition of a two-way shuttle-avoidance response and found that CDP-injected rats acquired the response faster than did control animals. This finding was in agreement with Zbinden & Randall's (1967) impressions that CDP attenuates fear and apprehension when the