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The effects of noncontingent reinforcement on the behavior of a previously learned running response

RICHARD S. CALEF, MICHAEL C. CHOBAN, MARCUS W. DICKSON, PAUL D. NEWMAN, MAUREEN BOYLE, and NIKKI D. BAXA
West Virginia Wesleyan College, Buckhannon, West Virginia

and

E. SCOTT GELLER
Virginia Polytechnic Institute and State University, Blacksburg, Virginia

During Phase 1, all rats received a delay of food reward following a traversal of a straight alley. During Phase 2, rats received contingent (CR), noncontingent (NCR), or no food reward (NR) in an operant chamber. During the 1st day of Phase 3 (running in the straight alley), no differences in speeds occurred between groups receiving contingent and noncontingent food. However, during the 3rd day of Phase 3, Group NCR ran significantly slower than Groups CR and NR, suggesting that noncontingent reinforcement does not interfere with the retention of prior learning, but may impair the further learning of a response partially learned prior to receiving uncontrollability (response-independent rewards).

Animals receiving inescapable, uncontrollable shock in one type of situation (e.g., barpressing) have performed worse with later exposed learning in a different situation (e.g., hurdle jumping) than animals exposed to an equivalent amount of prior escapable shock or no shock. This phenomenon has been called *learned helplessness* (e.g., Maier, Albin, & Testa, 1973; Overmeir & Seligman, 1967; Seligman & Beagley, 1975). According to Maier and Seligman's (1976) theory, inescapable shock interferes with the learning of a new response because inescapable shock causes animals to learn the concept of uncontrollability; this perception of uncontrollability causes the learning deficit termed learned helplessness.

Maier and Seligman's (1976) theory has been tested by research investigating the effects of noncontingent food on the learning of a new response in an appetitive situation (Oakes, Rosenblum, & Fox, 1982; Seligman, 1975; Wheatley, Walker, & Miles, 1977). If Maier and Seligman (1976) are correct, an appetitive situation that also produces uncontrollability should produce learning deficits in instrumental responding. Thus, finding that noncontingent positive reinforcement also produced deficits in learning was no surprise to these investigators.

The question arises as to whether the learned helplessness effect (LHE) in the aversive situation (inescapable shock) involves the same underlying mechanism as the LHE in the appetitive situation (response-independent food), especially since some studies (e.g., Beatty & Maki, 1979; Calef et al., 1984) have failed to find learning deficits in instrumental responding following exposure to noncontingent reinforcement. If learning deficits following inescapable shock and response-independent reward involve the same underlying mechanism, then other findings produced by inescapable shock should also be obtained by noncontingent reinforcement.

Recently, Calef, Choban, Shaver, Dye, and Geller (1986) found that inescapable shock interferes with the retention of a response previously learned. In this study, animals were trained to run down a straight alley for delayed food reinforcement during Phase 1. During Phase 2, rats were given escapable, inescapable, or no shock in an operant chamber. In Phase 3, animals were retested on the runway. The results showed inescapable shock subjects to run slower during the early stages of Phase 3 than escapable and no shock subjects did. The finding was named the *learned helplessness retention effect* (LHRE) by Calef et al. (1986). If learning deficits caused by inescapable shock involve the same underlying mechanism as learning deficits produced by response-independent food presentation, then the LHRE produced by inescapable shock should be replicated by noncontingent reinforcement.

The purpose of the present study was to investigate whether response-independent food would interfere with the retention of a response previously learned. During Phase 1, animals were trained to run down a staight alley for delayed food reward. Instead of exposing rats to escapable, inescapable, or no shock as in the Calef et al. (1986) study, we gave the animals contingent, noncontingent, or no food in an operant chamber during Phase 2. During Phase 3, the rats were again placed in the alley to test the retention of the response rewarded in Phase 1.

Reprints may be requested from Richard S. Calef, Department of Psychology, West Virginia Wesleyan College, Buckhannon, WV 26201.

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It was hypothesized that if learned helplessness produced by inescapable shock involves the same underlying mechanism as learning deficits caused by response-independent food, then noncontingent reinforcement subjects should run slower during Phase 3 than rats subjected to contingent or no reinforcement during Phase 2 (LHRE).

METHOD

Subjects

The subjects were 18 experimentally naive, male albino rats of the Sprague-Dawley strain, approximately 90 days old at the beginning of the experiment. The animals were obtained from Flow Laboratories, Dublin, VA, where they had been bred and reared. They were maintained on ad-lib water and were run during the light phase of the 12:12-h light:dark housing schedule.

Apparatus

A straight-alley food runway and three operant chambers were used. The alley was essentially the same as that used by Calef et al. (1986), except that the running and goal sections were painted black, and photocells and clock circuits provided an independent measure of traversal time over the first and last 30.5-cm (1-ft) segments of the start and run segments. The alley was composed of a 33.02-cm gray startbox, a 66.06-cm black runway section, and a 33.48-cm black goalbox. The inner width and height of each section were 12.5 and 16.5 cm, respectively. The walls and floors of the runway were constructed of plywood. The apparatus contained an opaque, Plexiglas ceiling and a white retrace door, which separated the goalbox from the alley section. A 1.5-cm opening at the bottom of the goalbox wall was made so that the goal cup could be placed in the box, 15 sec after the rat entered the box.

The three operant chambers used were 29 × 19.6 × 18 cm. The sides of the chambers and ceilings were constructed of clear Plexiglas. Centered on the right-hand panel was a 5-cm lever above the floor. To the right of the lever was a square goal cup that extended to the outside of the chamber so the experimenter could manually place pellets in it. The goal cup was approximately 5 cm above the floor.

Procedure

Fourteen days prior to the first day of training (Day 15), all rats were placed on a 23-h food-deprivation schedule, which was maintained throughout the study. On Days 7-14, the rats were taken from their individual home cages and handled for about 2 min each. On Days 13 and 14, the rats were taken to the experimental laboratory, where they were allowed to explore the start and run sections of the apparatus, while the clocks, photocells, and door were operated. On those days, approximately 1 g of 45-mg Noyes pellets, identical to the subsequent reinforcement pellets, was incorporated into the rats' daily food ration.

During Phase 1, all the animals were given 40 trials (4 trials/day) of continuous reinforcement (CRF) training with delayed (15-sec) rewards (food pellets) in the straight alley. Trials were administered to six squads of 3 rats, 1 subject per three experimental conditions during Phase 2. The running order of animals within a squad was randomized from day to day. The intertrial interval was approximately 4 min, since a subject did not receive its second daily trial until all the subjects in a squad had completed their first trials. The running trials during Phase 1 were initiated by the rats' being placed backwards in the startbox. Since there was no start door, all the rats were allowed to traverse the runway after they turned around in the startbox. After a rat entered the goalbox, the retrace door was dropped. After the pellets, each rat was removed from the apparatus. (The subjects were assigned to the groupings of 6 animals by matching running speeds during Phase 1.)

During Phase 2, a yoked-control design was employed, such that Group CR (contingent reinforcement) was shaped to barpress (the response lever was baited with a food pellet for 10 trials) for one pellet per response in an operant chamber. Group NCR (noncontingent reinforcement) received noncontinget rewards in another operant chamber at the same time that Group CR earned food. In other words, the amount of food was yoked across subjects in Groups CR and NCR. Group NR (no reinforcement) received no food, but during the same time of day, occupied an operant chamber that also contained a lever and a goal cup similar to those in the other chambers. Each squad completed its session when a Group CR subject attained 50 pellets. During the first week of Phase 2, Group CR received CRF training. During the next two weeks of Phase 2, Group CR received pellets on an FR2 reinforcement schedule.

During Phase 3, all the animals were given runway retention trials similar to those received in Phase 1, except that Phase 3 lasted for only 16 trials (i.e., 4 trials per day over 4 days).

RESULTS

Phase 1: Runway Trials

Only run times are presented, although start times showed similar results. Run times were converted to reciprocals to yield run speeds. Figure 1 illustrates mean speed per group as a function of consecutive days (i.e.,

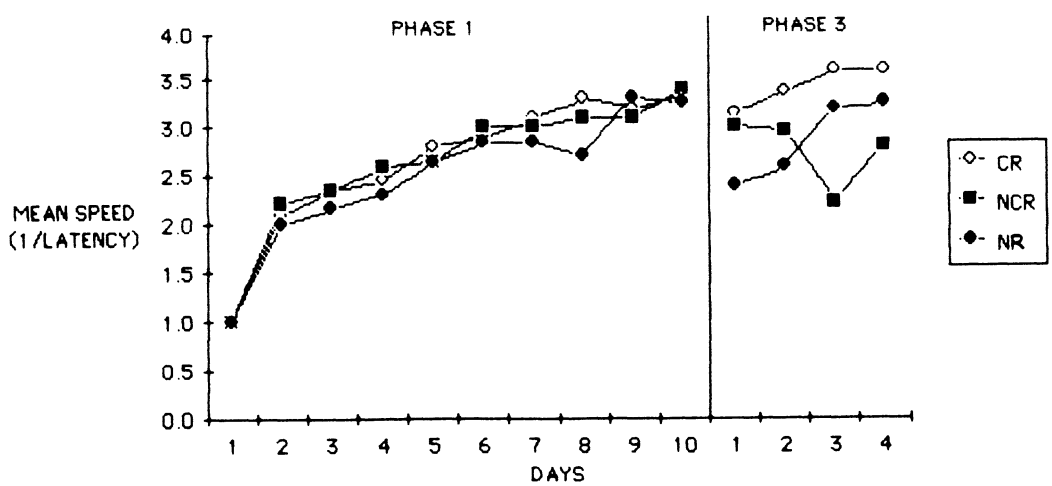

Figure 1. Group mean running speeds during Phases 1 and 3 as a function of days and reinforcement condition—that is, contingent reinforcement (Group CR), noncontingent reinforcement (Group NCR), and no reinforcement (Group NR)—during Phase 2.

blocks of 4 trials). As can be seen, all three groups ran at approximately the same speed during the last 2 days of Phase 1, since they were matched according to their running speeds during these days. A 3 (group) × 2 (day) analysis of variance (ANOVA) for the last 2 days yielded no significance ($p > .05$).

Phase 2: Operant Training

All of the subjects in Group CR learned to barpress. Over Days 1-21, Group CR barpressed at an average of 7-8 barpresses per minute.

Phase 3: Runway Retention Trial

As shown in Figure 1 (Phase 3), Group NCR ran approximately as fast as Group CR during Day 1 of Phase 3. However, during Day 3, Group NCR ran considerably slower than Groups CR and NR. In fact, Groups CR and NR increased their speeds over Days 1-4 during Phase 3, whereas the speeds of Group NCR remained stable over Days 1 and 2 and decreased considerably at Day 3.

A 3 (group) × 4 (day) factorial analysis was performed on the data from Days 1-4 during Phase 3. The analysis yielded a nonsignificant effect of group ($p > .05$), a significant effect of days [$F(3,60) = 5.51$, $p < .01$], and a significant group × day interaction [$F(6,60) = 3.37$, $p < .01$]. Correlated t paired comparisons between group mean running speeds showed Group CR to run equally fast as Group NCR on Day 1 of Phase 3 ($p > .05$). However, on Day 3, Group NCR ran significantly slower than Group CR ($p < .05$), and slower than Group NR, which approached significance ($p < .08$).

Phase 1 versus Phase 3

Figure 1 also shows Groups NCR and CR displaying a slight decrease in speed (loss of retention) from terminal Phase 1 (Day 10) to initial Phase 3 (Day 1) periods. However, Group NR showed a considerable decrement in speeds from Phase 1 to Phase 3.

A 3 (group) × 2 (phase) factorial ANOVA was performed on the data from Phase 1 (Day 10) and Phase 3 (Day 1). The repeated-measures analysis yielded a nonsignificant group effect ($p > .05$), a significant phase effect [$F(1,60) = 4.37$, $p < .01$], and a significant group × phase interaction [$F(2,60) = 3.96$, $p < .01$]. Correlated t-tests were performed on the data to interpret the interaction. The analysis found no significant difference ($p > .05$) between Phase 1 (Day 10) and Phase 3 (Day 1) speeds for Groups NCR and CR. However, the analysis did yield significance ($p < .05$) in comparing Phase 1 (Day 10) and Phase 3 (Day 1) speeds for Group NR.

DISCUSSION

The findings did not support the hypothesis that noncontingent reinforcement would interfere with the retention of an appetitive response, since Groups CR and NCR did not show differential speeds during Day 1 of Phase 3 or significant speed differences from terminal Phase 1 to initial Phase 3. If the LHE produced by inescapable shock involved the same underlying mechanism as the LHE produced by response-independent food, then the present findings should have replicated those of Calef et al. (1986), which showed inescapable shock to interfere with the retention of a previously learned appetitive response.

The present findings that noncontingent reinforcement did not interfere with the retention of a previously learned appetitive response indicates that response deficits caused by inescapable shock in the original studies (e.g., Maier et al., 1973; Overmeir & Seligman, 1967; Seligman & Beagley, 1975) may involve different underlying mechanisms than response deficits produced by noncontingent reinforcement (Oakes et al., 1982; Seligman, 1975; Wheatley et al., 1977).

The group × day interaction obtained during Phase 3 (Days 1-4) suggests that noncontingent reinforcement interferes with the additional learning of an appetitive response that was partially learned before exposure to uncontrollability. The fact that speeds during Phase 1 were still increasing indicates that the subjects had not fully learned the running response. This should not be surprising, since the rats were given delayed reward for only 40 trials during Phase 1. The fact that Groups CR and NR continued to show faster speeds as a function of days during Phase 3, but that mean speeds were either stable or decreasing for Group NCR during Days 1-3, suggests that noncontingent reinforcement during Phase 2 may have impeded further learning for Group NCR, at least temporarily.

Why Group NCR showed a decrement in running speed during Day 3 of Phase 3 is somewhat perplexing. This decrement may suggest an underlying mechanism to account for the learning deficit produced by noncontingent reinforcement. Animals receiving response-independent food may not learn the concept of uncontrollability, but rather become conditionally inactive due to receiving "something for nothing" during Phase 2. This learned inactivity may explain why Group NCR did not improve their running speeds over Days 1-3 of Phase 3.

The present findings conflicted with those of Calef et al. (1984). In the latter study, the authors found noncontingent reinforcement to facilitate rather than inhibit the acquisition of a running response in the straight alley. The contrary findings may be attributed to the different training procedures in the two studies. In the present study, delay of reinforcement following an alley traversal was used, and the subjects were partially trained to run before being introduced to response-independent food. In the Calef et al. (1984) study, the subjects were given immediate reward after a runway response and were trained to run only after being introduced to uncontrollability.

Lastly, the present study showed only Group NR to experience a loss of retention from Phase 1 to Phase 3. These results are contrary to the findings of Calef et al. (1986). Group NS (no shock) in the prior study was treated the same as our NR control group. Yet the NS group in the earlier study displayed very little loss of retention. The conflicting results could be explained by the fact that in the present study, 3 weeks separated Phase 1 and Phase 3, whereas in Calef et al. (1986), only 1 week separated Phases 1 and 3. In the present study, Group NR did not receive any reinforcement pellets during Phase 2, whereas Groups NCR and CR obviously did.

Possibly for Groups CR and NCR, the long retention gap was bridged by the discriminative stimulus value of the pellets received from running in the alley. With the short interval used by Calef et al. (1986), Group NS did not need a discriminative stimulus to bridge the gap, and thus showed good retention during Phase 3.

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