Determinants of rate of extinction in successive acquisitions and extinctions

ALLEN H. WOLACH, KENNETH LATTA II, DENNIS MANSHIO
and MORRIS ADERMAN

Illinois Institute of Technology, Chicago, Ill. 60616

Rats were used in an investigation of the conditions that are necessary to obtain a decrease in resistance to extinction across extinctions in a successive acquisition and extinction paradigm. Long breaks (23.5 h) after extinction coupled with a short intertrial interval within extinction sessions (long N-R transition) resulted in a decrease in resistance to extinction across the successive extinctions. Long breaks after acquisition sessions (long R-N transition), or in the middle of acquisition sessions (long R-R transition), yielded an increase in resistance to extinction across the successive extinction sessions. When extinction sessions followed immediately after acquisition sessions (N-R), Ss decreased their running speeds within each of the successive extinctions. When acquisition sessions followed immediately after extinction sessions (R-N), Ss decreased their running speeds within the first few successive extinctions. The R-N Ss learned to increase their running speed within extinctions during the later successive extinctions.

Successive acquisition and extinction studies with rats as Ss have produced increased or constant levels of resistance to extinction across extinctions (e.g., North & Morton, 1962) and decreased levels of resistance to extinction across extinctions (e.g., Bullock & Smith, 1953). Capaldi, Leonard, & Ksir (1968) noted that most of the short intertrial interval studies had the last extinction trial in each of the successive extinctions followed by a very long intertrial interval (approximately 23.5 h). The long break between extinction and acquisition (N-R) was very discriminable from the shorter break between any two nonreinforced extinction trials (N-N) that occurred in a daily extinction session.

Capaldi, Leonard, & Ksir (1968) posited that discriminable N-N and N-R transitions provide the opportunity for a decrease in resistance to extinction across successive extinctions. Lauer & Estes (1955) have suggested that the operations involved in partial reinforcement and successive acquisitions and extinctions converge into a common paradigm. That is, the successive reinforced and the successive nonreinforced trials in a partial reinforcement situation can be considered to be "miniature" acquisition and extinction sessions. If partial reinforcement and successive acquisitions and extinctions are regulated by identical principles, it should be possible to obtain similar acquisition and extinction performance employing relatively long acquisition and extinction sessions and relatively short acquisition and

extinction sessions. The Capaldi, Leonard, & Ksir (1968) study was limited to the short acquisition (four trials) and extinction situation. The present investigation has longer acquisitions (20 trials) and extinctions (15 trials). In addition, the placement of the 24-h period that ended a daily session was varied for the three groups. That is, one group experienced this break at the end of acquisition, another group experienced the break at the end of extinction, and a third group experienced the break in the middle of acquisition sessions.

METHOD

Subjects

Twenty-one naive Sprague-Dawley rats, 130-135 days old, served as Ss. The Ss were housed three to a cage with water freely available. Eight 2.54-cm Wayne Lab Blox pellets were placed in each cage on a 24-h schedule for the 2-week period prior to the initiation of experimental procedures. During the study, Ss were fed after the last S in a cage completed its experimental session. The 21 Ss were assigned randomly to three groups of 7 Ss, and each S was run at the same time every day. All of the Ss in a given cage were run before the next cage was started. The Ss were run in squads of 9, with a new squad started every 4th day.

Apparatus

A straight alley runway was used in this study. Both ends of the runway terminated in equal-sized end compartments (33.02 x 12.70 x 12.70 cm). The center section of the runway was 139.70 cm long and had the same height and width as the end compartments. Two guillotine-type doors separated the end compartments

from the rest of the runway. A third guillotine-type door was located at the middle of the center section of the runway. The walls and floor of the runway were made of wood and painted flat black. The top of the runway consisted of hinged frames (one for each end compartment and two for the runway) with aluminum screening in each frame so that the E was able to view S in the runway. Food pellets were placed on the last 2.54-cm section of an end compartment when they were required.

Procedure

Three experimental groups were used in this study. The first group (N-R) experienced the long break that ended a daily session (23.5 h) between an extinction and the subsequent acquisition session. The Ss in this group experienced 20 acquisition trials, followed by 15 extinction trials each day on each of 7 consecutive days. That is, Ss in this group experienced the long break that ended a daily session after each of the successive extinctions.

The second group (R-N) experienced 20 acquisition trials on the first day of training. Six days of training with 15 extinction trials followed by 20 acquisition trials occurred on each day of Days 2-7. Day 8 consisted of 15 extinction trials. The Ss in this group experienced the long break that ended a daily session after each of the successive acquisitions.

Group 3 (R-R) experienced the long break in the middle of acquisition sessions. The 1st day of training consisted of 10 acquisition trials. Days 2-7 were initiated with 10 acquisition trials, followed by 15 extinction trials, and concluded with 10 acquisition trials. The 8th day of training consisted of 10 acquisition trials followed by 15 extinction trials.

In summary, the three groups differed in the placement of the 23.5-h period that ended a daily session. Intertrial intervals within daily sessions were constant for the groups. All groups shuttled from one end of the runway to the other. That is, running direction was alternated from trial to trial. A given S always began its first trial of the day on the same side of the runway. Timing of the first trial started when S's feet were placed on the end compartment floor. Timing of the trial was ended when S was 17.8 cm into the end compartment at the other end of the runway and the guillotine-type door closed behind it. The door remained closed for a 5-sec period. At the end of the 5-sec period, the door was raised so that S could run to the other side of the runway for the next trial. Timing on all trials

Fig. 1. Successive acquisitions and extinctions for groups experiencing the long break that ended a daily session between acquisition and extinction (R-N), extinction and acquisition (N-R), or in the middle of acquisition sessions (R-R). The points representing acquisition are not connected to the extinction points.

subsequent to the first one was initiated by the raising of the guillotine-type door that confined S, and terminated when the door at the other end of the runway was lowered. If S did not finish a trial in 90 sec, it was assigned a score of 90 sec and pushed to the appropriate end of the runway for the 5-sec confinement period. During acquisition trials, two .045-g Noyes pellets were available in the last 2.54-cm section of the appropriate end compartment.

RESULTS AND DISCUSSION

A repeated measures analysis of variance was performed on the Ss' speeds (1/running time in seconds) from the acquisition sessions (Successive Acquisition Session by Experimental Group) to ascertain if the experimental groups differed during the successive acquisitions. The sum of the last 19 trials for each S during each acquisition session was used as the basic datum in the analysis of variance. The first acquisition trial from each acquisition session was not used because this trial was essentially an extinction trial. The three experimental groups did not differ from each other, $F(2,18) = 2.45$, $p > .05$. A significant successive acquisition session effect was obtained, $F(6,108) = 68.90$, $p < .01$. The Successive Acquisition Session by Experimental Group interaction was also significant, $F(12,108) = 1.90$,

$p < .05$. The data from the acquisitions revealed that the performance of the three groups was similar when going into each of the extinction sessions. Figure 1 shows the acquisition speeds that preceded each of the successive extinctions.

A three-way analysis of variance with repeated measures on two factors (Experimental Group by Successive Extinction by Extinction within a Session) was performed on the extinction data. The extinction data from a given S consisted of the average of its running speeds in five trial blocks for each of the successive extinctions. The experimental group effect was significant, $F(2,18) = 4.02$, $p < .05$. Further tests showed no differences between Groups N-R and R-R, $F(1,12) = 2.59$, $p > .05$, or between Groups R-R and R-N, $F(1,12) = 2.43$, $p > .05$. Groups N-R and R-N differed significantly from each other, $F(1,12) = 8.46$, $p < .05$.

The three-way analysis of variance produced a significant successive extinction session effect, $F(6,108) = 4.50$, $p < .01$, and a significant Successive Extinction by Experimental Group interaction, $F(12,108) = 2.16$, $p < .05$. Figure 1 shows an apparent increase in resistance to extinction across successive extinctions for Groups R-N and R-R. The figure also shows a decrease in resistance to extinction across extinctions for

Group N-R. The significant interaction for experimental groups and successive extinctions supports this observation. The significant main effect for successive extinctions suggests that when all groups are combined, the increase in resistance to extinction for Groups R-R and R-N is sufficient to overcome the decrease in resistance to extinction for Group N-R.

Repeated measures analyses of variance were used to determine if the increase in resistance to extinction across extinctions for Groups R-R and R-N was significant. A similar test was computed to determine if the decrease in resistance to extinction after the second extinction was significant for Group N-R. Groups R-R and R-N showed a significant increase in resistance to extinction from the first to the last extinction session, $F(1,6) = 9.0$, $p < .05$, and $F(1,6) = 9.73$, $p < .05$, respectively. The decrease in resistance to extinction on the 7th (last) day of extinction relative to the 2nd day of extinction for Group N-R was significant, $F(1,6) = 12.46$, $p < .05$. It should be noted that all seven Ss showed a decrease in resistance to extinction from the 2nd to the 7th day of extinction.

The Capaldi, Leonard, & Ksir (1968) position predicts that only the group with the long break occurring between extinction and acquisition (N-R) would have the opportunity to discriminate N-R and N-N trials, and thus show a decrease in resistance to extinction across extinctions. The results obtained from the raw extinction data support this position.

Groups R-R (long break ending a session occurring between two acquisition trials) and R-N (long break between acquisition and extinction) were included because they are representative of two of the many ways of breaking up daily sessions without providing opportunity for an N-R vs N-N discrimination. Capaldi's position predicts a decrease in resistance to extinction for groups with discriminative N-R transitions. Consequently, the increase in resistance to extinction across extinctions for the two groups without discriminative N-R transitions is consistent with Capaldi's hypothesis.

Capaldi, Leonard, & Ksir (1968) observed an increase in resistance to extinction for their N-R group during the first five successive extinctions followed by the predicted decrease in the remaining extinctions. The increasing part of the function could have been caused by the relatively incomplete training afforded by the short acquisition sessions that they used, i.e., short acquisition sessions probably make an N-R vs N-N discrimination more difficult, since the

relative numbers of N-R and N-N transitions are more similar. The present study used longer acquisition and extinction sessions and produced a maximum in resistance to extinction by the end of the second extinction session.

The three-way analysis of variance (Experimental Group by Successive Extinction by Extinction within a Session) produced a significant extinction within a session effect, $F(2,36) = 6.85$, $p < .01$, and a significant Extinction within a Session by Experimental Group effect. The interaction supports the observation that Group R-N produced a conventional extinction pattern within the first two extinctions; i.e., Ss decreased their running speeds with the first two extinctions. By the seventh extinction, R-N Ss appear to increase their running speeds within extinction sessions. An analysis of variance performed on the data from R-N Ss during the first and seventh extinctions reveals a significant Successive Extinction by Extinction within a Session interaction, $F(2,24) = 3.60$, $p < .05$. This interaction

supports the observation that the extinction pattern within sessions for R-N Ss changed from decreasing resistance to extinction to increasing resistance to extinction. Figure 1 reveals that R-R and N-R Ss showed a conventional decrease in resistance to extinction within sessions during each of the seven extinctions.

Capaldi's theory cannot explain the change in extinction pattern within extinctions for the R-N group relative to the consistent extinction pattern within extinction sessions for the R-R group. Both of these groups had the same short intertrial interval between extinction and acquisition sessions. An explanation for these results is suggested by the different kinds of cues that are available to R-N and R-R Ss. Since R-N Ss start daily sessions with extinction and terminate daily sessions with acquisition, nonreinforced trials can become a discriminative stimulus for the acquisition that follows immediately after every extinction. A S can learn to increase his running speed across extinction trials, much like a leverpressing S develops a

fixed-interval scallop when it is placed on a fixed-interval schedule. The R-R Ss have nonreinforced trials between blocks of reinforced trials during each daily session. Nonreinforcement signals the end of acquisition sessions and the beginning of acquisition sessions. Consequently, it is more difficult for R-R Ss relative to R-N Ss to learn that reinforcement follows immediately after every extinction.

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