Reacquisition and stimulus specificity¹

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As a test of the modified aftereffects hypothesis and, more particularly, the stimulus specificity assumption, a three-phase instrumental reward learning (runway) experiment was conducted with albino rats. The stimulus specificity position was supported by the finding of a "reversed" PRE in the second phase (extinction) but was not supported by the results of the third phase (reacquisition).

The modified aftereffects hypothesis (Capaldi, 1967) views the partial reinforcement effect (PRE) as a special case of transfer of training. In accord with this position is a recent experiment (Spivey, Hess, & Black, in press) in which both a PRE and a "reversed" PRE were obtained. The present investigation constituted a further test of the transfer of training interpretation.

SUBJECTS

The Ss were 30 naive, 90-day-old, male albino (Sprague-Dawley) rats which were obtained from the Holtzman Co. of Madison, Wisconsin. Ten Ss were randomly assigned to each of the three groups. Throughout the experiment Ss were housed in individual cages, where tap water was continuously available, and were maintained on a 23-h food deprivation schedule which consisted of a 1-h ad lib feeding of wet mash (Rockland Rat/Mouse Diet meal mixed with tap water) beginning 15 min after the end of each day's training.

APPARATUS

The apparatus was a 77 in. long x 4 in. wide x 9 in. deep plywood runway which was covered with hinged lids of hardware cloth. The 65-in. mid-gray alley section was separated from the 12-in. flat-black goalbox (GB) by a manually-operated aluminum guillotine-type door which was used to prevent retracing. A two-compartment brass food cup was housed at the rear of the GB in a notch created by removing the bottom 1-5/8 in. of the rear wall and the last 2 in. of the side walls to a height of 1-5/8 in. The food cup could be moved perpendicular to the runway so that only one of the two compartments was in the GB at a time. Each compartment measured 2 in. from front to back, 4 in. from side to side, and 1-1/2 in. in height. The cup was covered with a tight-fitting brass lid which prevented the contents of a compartment from being exposed until S interrupted the last photobeam (located 3 in. in front of the cup) and, thereby, activated a small noiseless motor which caused the lid to be pulled swiftly through the rear of the GB.

A floor treadle suspended over a microswitch in the initial 9 in. of the alley and three photocells located 4 in., 54 in., and 64 in. beyond the treadle were connected to three Standard electric timers, calibrated in .01 sec, for measuring running times in the 4-in. start section, the 50-in. run section, and the 10-in. goal section.

For the present report the section times were summed to give a total running time for the 64-in. distance. Except for the faint "click" of the Standard electric timers, the circuitry operated silently; Hunter model 31 photocells, positioned opposite Hunter model 30 light sources with infrared filters, were associated with Hunter model 335 S series D photo relays and Hunter model 111 C series D decade interval timers.

PROCEDURE

The Ss were maintained on ad lib food (Rockland Rat/Mouse Diet pellets) for 10 days and then were given 11 days to adjust to the deprivation schedule (Days 1-11 of training). On each of the next four days each S was individually handled, at the approximate time S was to be run, in the experimental room for 15 min on a 24 in. x 28 in. unpainted wooden platform with wet mash continuously available from a glass coaster. On Days 16 and 17 each S was placed on the treadle and was allowed to explore the alley for 5 min. The motor was disconnected so that the food cup would remain closed. On Day 18 each S was given two 1-min R placements in the GB, each of which was followed by a 1-min confinement in the 12-in. sq x 24-in. deep unpainted wooden intertrial interval (ITI) box. S was placed at the front of the GB, and the food cup lid was retracted as S advanced through the photobeam.

On Day 19 Ss were given two running trials, NR (Group N-R), RR (Group R-R), or RN (Group R-N). Days 20-34 constituted three five-day phases of training with four trials being given on each day. During "Acquisition," Days 20-24, the reinforcement patterns were NNNR (Group N-R), RRRR (Group R-R), and RNNN (Group R-N). During "Extinction," Days 25-29, each group received only nonreinforcement (NNNN), while on Days 30-34, or "Reacquisition," each group received consistent reinforcement. On Days 19-34 the GB confinement duration and the subsequent ITI were each 15 sec. On R trials S

was confined with the food compartment which contained wet mash; on N trials S was confined with the empty food compartment while wet mash was present, but not visible, in the adjoining compartment. A random schedule was employed to determine whether the food would be in the left or in the right compartment on any specific day even though the presence of a 1-5/8 in. strip of brass which ran the width of the GB in front of the food cup eliminated the possibility of visual cues.

On Days 18-34 S was confined to the ITI box, for the period of time called for on that particular day, not only after each trial but also prior to the first trial. The forcing criterion on all running trials was 60 sec; if S did not complete a section of the runway within this time, S was gently forced into the last photobeam and 60 sec was recorded for each uncompleted section.

RESULTS

For all statistical analyses the elapsed time measurements were converted to logarithms. The group means for each day of training are displayed in Fig. 1. Although the groups did not differ on Trial 1 of acquisition ($F < 1.00$, $df = 2/27$) their overall acquisition performance levels were reliably dissimilar; for the Groups variable $F = 9.29$, $df = 2/27$, $p < .001$, and for the Groups by Trials interaction $F = 3.10$, $df = 38/513$, $p < .001$. A Duncan's multiple range test indicated that Group R-N significantly differed from Groups R-R and N-R ($p < .005$, $p < .001$, respectively), while the two latter groups did not differ ($p > .10$). It might be said that Group R-N did not even display an acquisition curve, for the daily means are almost identical.

In extinction both the group differences and the interaction of groups with trials were highly significant ($F = 24.64$, $df = 2/27$, $p < .001$, $F = 3.93$, $df = 38/513$, $p < .001$, respectively). A Duncan's multiple range test was applied to the group means and revealed that Group N-R ran significantly faster than either of the other two groups ($p < .001$ for each comparison); Groups R-R and R-N differed at the .05 level.

The apparent acceleration of Groups R-N and R-R over Days 3-5 is misleading since both groups showed clear "extinction" curves within each day. For both groups the decrease in daily mean time was due to a successive lowering of the daily extinction asymptotes between Days 3 and 5.³ However, the two groups differed markedly in the way in which the daily asymptotes were attained. While Group R-R displayed a gradual slowing down over Trials 1-4 each day, Group R-N effectively achieved one-trial extinction each day. The exception was Day 4, on which both groups reached the day's asymptote on Trial 3.

In the third phase of training, reacquisition, the groups differed ($F = 3.79$, $df = 2/27$, $p < .05$) but the Groups by Trials interaction was not significant ($F = 1.29$, $df = 38/513$, $p > .10$). Again Duncan's multiple range test was employed to further assess the group differences. While Group N-R ran faster than either Group

Fig. 1. Group mean log running time for each of the 15 days of training.

R-R or Group R-N ($p < .05$ in each case), the two latter groups were statistically equivalent ($p > .10$).

Surprisingly, the plots of the daily means for each group were curvilinear. An examination of the trial-to-trial changes in running times within each day revealed two opposing tendencies. On the one hand each group on Trial 1 ran successively faster on Days 1-5 (except that Groups N-R and R-R ran slightly slower on Day 5 than on Day 4). On the other hand, if the daily means for Trials 2-4 are considered, deceleration occurred over Days 4-5 (Group N-R), Days 3-5 (Group R-R), or Days 2-5 (Group R-N). It should be indicated at this point that in acquisition Group R-R ran successively faster over Days 1-5 as measured either by Trial 1 or by the mean for Trials 2-4.

DISCUSSION

In the present investigation and in a previous study (Spivey, Hess, & Black, in press), as contrasted with two earlier experiments (Spivey & Hess, 1968; Spivey, Hess, & Black, 1968), R-N transitions both depressed acquisition performance and resulted in a reversal of the PRE. The source of the disparity between these two pairs of experiments could be either the reinforcement patterns employed or the level of training which was given.

Although the modified aftereffects hypothesis is mainly the product of research with partial reinforcement (Capaldi, 1966a), the stimulus specificity assumption (Capaldi, 1966b) yields predictions concerning the performance of albino rats in a wide variety of instrumental reward learning situations (Capaldi, 1967). While research with partial reinforcement has provided strong support for this position, the hypothesis thus far has been applied to only a small assortment of experimental problems. The third phase of training was included in the present experiment primarily as a test of the stimulus specificity assumption. The same rationale which led to the prediction that in the second phase Group N-R would run fastest and Group R-N would run slowest also led to the expectation that in the third phase the groups would be ordered R-R, N-R, R-N, with Group R-R being the fastest running group.

In the third phase the aftereffect of reinforcement (S^R) should have been a dominant part of the stimulus complex on each trial after the first trial, and running speed should have been a function of the capacity of S^R to evoke running. Only for Group R-R was S^R directly conditioned; the strength of this conditioning should have been diminished somewhat in extinction by generalized inhibition from S^N . Group R-N supposedly acquired inhibition for S^R and S^N in Phases 1 and 2, respectively, and should have run slower than the other two groups in Phase 3. For Group N-R running in the third phase should have depended on the generalization of associative strength from S^N to S^R ; thus this group should have run slower than Group R-R but faster than Group R-N. Note also that in Phase 2 Group N-R, but not Group R-R, received direct extinction of the aftereffect which was conditioned in Phase 1.

Each of the three groups ran faster on every day of the third phase than it had run on any day of Phase 1. This result, for Group R-R, agrees with the finding in other studies (Bullock & Smith, 1953; North & Morton, 1962) that reacquisition may be faster than original learning. Still other investigators (Cotton, Hill, & Clayton, 1967; Cotton & Jensen, 1963; Jensen & Cotton, 1960; Lauer & Carterette, 1957) have claimed that extinction training actually facilitates reacquisition.

To interpret the results of these designs involving successive acquisitions and extinctions various "discrimination" hypotheses have been invoked (Bullock & Smith, 1953; Logan & Wagner, 1965; Perkins & Cacioppo, 1950). stimulus sampling theory has been entertained (Lauer & Estes, 1955) along with a habituation hypothesis (Lauer & Carterette, 1957; Lauer & Estes, 1955) and a contiguity assumption (Cotton, Hill, & Clayton, 1967; Cotton & Jensen, 1963; Jensen & Cotton, 1960), and the stimulus specificity hypothesis has been forwarded (Capaldi, 1967). However, not one nor any combination of these views would be

adequate to elucidate the spectrum of results which was obtained in Phase 3 of the present investigation.

Although the curvilinear function displayed by each group in the third phase might suggest something akin to elation and recovery, as sometimes found in studies involving shifts in reinforcement magnitude (but see Spear, 1967), this common-sense view would still not predict the obtained group ordering.

Further research with the effects of partial reinforcement patterns on successive acquisitions and extinctions is needed. Partial reinforcement was employed by Perkins & Cacioppo (1950), by Lauer & Estes (1955), and by Jensen & Cotton (1960); however, in the first experiment the reacquisition data were not reported, in the second experiment partial reinforcement and consistent reward were alternated across successive acquisition periods, and in the third experiment all groups were not subjected to a comparable extinction period between acquisition sessions.

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NOTES

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2. Now at the State University of New York at Fredonia.

3. The acceleration of Groups R-N and R-R was not unexpected. We have obtained this result in several previous experiments, usually involving abbreviated acquisition training, in which extinction training has been extended over several days. We have found that if a group extinguishes very rapidly it may later accelerate, as measured by daily means, if extinction training is prolonged.