Synthesis of double alley and discrimination phenomena: Apparent positive S^+ contrast in differential conditioning¹

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Twenty-four albino rats received 108 trials in a differential conditioning apparatus with the sequence of discriminandum presentation designed to simulate L-shaped double-alley procedures. Discrimination animals ran faster to large reward than did nondiscrimination (control) animals.

In recent years several experimental procedures have been used to determine how the performance of rats to a specific magnitude of reward is affected by the organism's experience with other reward magnitudes. Despite the general common interest in relative or contextual reinforcement effects, largely separate bodies of literature have evolved from the use of the L-shaped double-alley apparatus (cf. Amsel, 1962) and from experiments employing a simple differential conditioning apparatus (cf. Dunham, 1968). The present experiment represents an initial attempt at the synthesis of the data obtained in these two research areas.

Discrimination contrast studies have concentrated on how responses to stimuli (S_2) associated with one magnitude of reward are influenced by the reward received for response to a different stimulus (S_1). In the double alley, the effects of reinforcement manipulations in the first alley (S_1) on performance to a specific reward in the second alley (S_2) have received considerable attention. Complementing this procedural similarity, noted by Daley (1968), certain functional similarities have been obtained. For example, speeds to a specific small reward in S^- (S_2) are inversely related to the amount of reward received in S^+ (S_1) in differential conditioning (Ludvigson & Gay, 1967). Similarly, speeds to small reward in the second alley (S_2) are inversely related to the amount of reward received in the first alley (S_1) (McHose & Ludvigson, 1965). These differential conditioning and double alley effects are labeled, within the separate literatures, "S- contrast" and "absolute magnitude effects," respectively.

While certain functional and procedural similarities suggest that the double alley training procedure may be viewed as discrimination training, at least one behavioral effect obtained in the double alley

situation does not appear analogous to that obtained in differential conditioning. In discrimination studies, speeds to large reward in S_2 are depressed (by small reward in S_1) relative to those of a (nondiscrimination) group which always received the larger reward (MacKinnon, 1967). In the double alley, however, speeds to large reward in the second alley (S_2) are faster for groups that receive small reward in S_1 than for a group which receives the larger reward in both S_1 and S_2 (Daly, 1968). The proposed analogy between double alley and discrimination procedures, however, does not imply that all procedures are similar. Indeed, the double alley training procedure is a peculiar discrimination training technique since S_1 always precedes S_2 and the intertrial intervals on S_1 as compared with S_2 trials are systematically different. In the present study, a brightness discrimination training procedure more analogous to the double alley mode of S_1 - S_2 presentation was employed in order to ascertain whether the proposed analogy between double alley and differential conditioning procedures merits further attention.

METHOD

A total of 108 trials was administered to 24 naive, 90-day-old albino rats in a brightness discrimination apparatus. The apparatus, described in detail elsewhere (McHose, Meyer, & Maxwell, 1969) was comprised of a gray start box (SB) and two moveable straight alley-goal sections, one painted flat black, the other flat white. Each alley-goal section could be aligned with SB. A solenoid-operated, side-exit start door separated SB from the aligned alley-goal section, and a translucent retrace door, normally open, was positioned between the alley and goal sections. Opening the start door activated a Hunter Klockcounter which stopped when S interrupted a photobeam located 12 in. from SB, providing a start time. Photocell-clock circuitry also provided a run time measure over the next 12-in. segment of the alley.

Thirteen days prior to the first training day (Day 14), Ss were placed on a 23-h food-deprivation schedule maintained throughout the experiment. On Days 11, 12, and 13 each S was handled for approximately 5 min, allowed 3 min exploration of the alley sections of the apparatus, and fed eight 45-mg Noyes pellets, identical to the subsequent reinforcement pellet, in addition to its regular 1-h feeding.

Twelve Ss were assigned to each of two groups, Groups 1-8 and 8-8, designated according to the number of pellets of reward

received on odd- and even-numbered daily trials, respectively. For both groups, odd-numbered trials were administered in one brightness (e.g., black alley) and even-numbered trials in the other brightness condition (white alley). The brightness associated with odd-(even-) numbered trials was counterbalanced within Groups 1-8 and 8-8. The reinforcement cycle was thus one of single alternation between one- and eight-pellet trials for Group 1-8 with alley-goal brightness correlated with reward condition. Ss received four trials per day with the intertrial interval (ITI) on Trials 2 and 4 approximately 8 sec. The ITI on Trial 3 was approximately 8 min. During the longer ITI, S was returned to a carrying cage with water available in the cage. On short ITI trials, S was placed in a wire-mesh cage while E repositioned the alley-goal sections and baited the goal box. Trials were administered to squads of eight Ss each, two from each subgroup with the first S in a squad receiving its first and second daily trial before the second S received its first two daily trials, etc. The running order of Ss within a squad was randomized from day to day.

On Days 14-37, the start door was opened following a 3-sec orienting response. On the last two days of the experiment, E placed S in SB, counted 1 sec and opened the start door. Throughout the experiment, S was removed from the goal section immediately after eating.

Start and run times were reciprocated, yielding start and run speeds, respectively.

RESULTS

Group mean start and run speeds as a function of blocks of 20 (Blocks 1-5) or eight trials (Block 6) are presented in Fig. 1. For Group 1-8, speeds on eight-pellet trials (S^+) are plotted separately from those on one-pellet trials (S^-). Similarly for Group 8-8, the speeds obtained on odd-numbered trials (" S^- ") are plotted separately from those obtained on even-numbered trials (" S^+ "). The vertical line at Block 5 indicates the point at which the procedure for opening the start door was changed.

Looking first at the preshift data, it may be seen in Fig. 1 that Group 1-8 eventually ran faster on S^+ trials than on S^- trials in the start segment, this difference disappearing in the run measure. Group 8-8, however, displayed faster speeds on " S^- " trials than on " S^+ " trials, particularly in the run measure.

Variance analysis of the data on S^+ and S^- trials over Blocks 4 and 5 for Groups 8-8

Fig. 1. Start and run speeds as a function of blocks of trials.

disparity is, of course, easily attributed to any one of several variables systematically confounded with the differential reinforcement contingencies in S_1 and S_2 , confounds which result from the alternating S_1 - S_2 presentations in the present study and from the differential intertrial intervals on S_1 and S_2 trials. For present purposes, however, what is of primary interest in the present $S+$ data is the tentative link which they provide between differential conditioning and double alley data.

As suggested earlier, the double alley situation in which rats traverse two alleys in series may be viewed as a discrimination training procedure in which S s receive different rewards for traversal of the first (S_1) and second (S_2) alleys. Viewed in this fashion, some results obtained in the double alley apparatus are analogous to those obtained in differential conditioning experiments. However, the observation that S s which receive small reward in S_1 run faster to large reward in the second alley (S_2) than do S s which receive the same large reward in S_1 and S_2 is not analogous to previous discrimination data (MacKinnon, 1967). In the present discrimination data, however, the observation that Group 1-8 ran faster to $S+$ (S_2) than did Group 8-8 under S_1 - S_2 presentation sequences is functionally analogous to the double alley result. The present data do not demonstrate the validity of viewing the double alley procedures and attendant behavioral effects as differential conditioning phenomena. Rather, they suggest that previous data apparently inconsistent with such a viewpoint may be attributed to the peculiar mode of stimulus presentations employed in the double alley experiment. When the stimulus presentation techniques are simulated in the differential conditioning situation, as was the case in the present study, the data are consistent with an "analogy" frame of reference.

Finally, certain limitations should be placed upon the interpretation of the behavior of Group 1-8. While performance was faster to $S+$ than to $S-$, the present data afford no direct evidence that this differential performance results from differential reward in $S+$ and $S-$, i.e., that S s in this group did indeed "discriminate" between S_1 and S_2 . For example, the single alternation method of presenting $S+$ and $S-$ raises the possibility that $S+$ speeds differed from $S-$ speeds as a result of differential reward magnitudes on immediately preceding trials. However, the effect of changing the procedure for opening the start door is suggestive of a discrimination learning

and 1-8 yielded a significant ($p < .001$) $S+$ vs $S-$ by Groups interaction in both start and run measures, $F_s = 27.11$ and 27.28 , $df = 1,22$, respectively. Subsequent pair comparisons (Tukey t tests) indicated that in both measures Group 1-8 ran significantly ($p < .05$) faster on $S+$ trials than did Group 8-8, but slower on $S-$ trials. Within- S pair comparisons (t tests) indicated that Group 1-8 ran significantly ($p < .01$) faster on $S+$ as compared with $S-$ trials in the start measure, but not in the run measure. Group 8-8 ran significantly faster on $S-$ trials in both the start and run measures.

As may be seen in Fig. 1, changing the procedure for opening the start door had little effect on the ordinal arrangement of speeds for the various conditions with the exception of a pronounced decrease in speeds on $S-$ trials for Group 1-8. Analysis of variance of the data for both groups at Block 6 yielded results similar to that obtained in analysis of the preshift data. Thus the Groups by $S+$ vs $S-$ interaction was again significant ($p < .01$) in both start,

$F = 51.69$, $df = 1,22$, and run, $F = 18.59$, $df = 1,22$, measures. In the subsequent pair comparisons, the Block 6 data differed from the preshift data only in the run measure where the speeds of Group 1-8 were significantly ($p < .01$) faster on $S+$ than on $S-$ trials. Finally, variance analysis of the data for Group 1-8 on pre- and postshift trials (Block 5 vs Block 6) yielded a significant $S+$ vs $S-$ by Trial Block interaction in the start measure only, $F = 13.35$, $df = 1,11$, $p < .01$.

DISCUSSION

In the present study, the discrimination group, Group 1-8, displayed faster speeds in the alley associated with large reward (S_2) than did a nondiscrimination control condition, Group 8-8, which received large reward in both S_1 and S_2 . In this respect, these data are quite unlike previous differential conditioning data (MacKinnon, 1967) which show performance to $S+$ for a discrimination group depressed relative to the performance level of S s which always receive the $S+$ reward magnitude. This

effect. Essentially, the start door procedure employed in the later trials consisted of opening the door immediately after placing S in the start box (SB). Under these conditions, S— speeds for Group 1-8 showed a marked decline from the level obtained when S was detained in SB for 3 sec. Assuming, with Capaldi (1967), that large and small rewards occasion specific stimulus aftereffects which are reinstated by apparatus cues, these stimuli would serve as cues in SB for the reward to be received on any trial. In the postshift period, runway measures were taken as soon as S was exposed to these cues, a procedure which is more sensitive to differential response tendencies to S— as compared with S+ (Ludvigson & Gay, 1967).

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- NOTES
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both features after training.

SUBJECTS AND APPARATUS

The Ss were 5- to 6-year-old male White King pigeons which were run at approximately 80% of their free-feeding weight.

The basic apparatus was three automatic key-pecking boxes with response keys which could be backlighted. The experiment was controlled by five channel tape readers, relay switching circuits, and timers. Total counts of various events were recorded on impulse counters.

Auditory stimuli were either a tone at 1000 cycles or a broad-band white noise. When tone was switched on noise was switched off. Either tone or noise was on throughout the experimental sessions. The intensity of both tone and noise was maintained at 80-dB sound pressure. Visual stimuli were different brightness levels of the key which were procured by varying the voltage across the stimulus lamp. These were designated L1(24.3 V), L2(21.9 V), L4(19.1 V), L5(16.3 V). A dark key (0 V) was designated D.

PROCEDURE

Subjects were initially shaped to peck a lighted key with the tone on, and were then given four sessions of pretraining. Each session consisted of 40 trials separated by an intertrial interval (a dark key and white noise were present) ranging from 35 to 90 sec. Throughout all experimental sessions the houselight was on. Trials began with the illumination of the response key and the onset of the tone. If S completed the response requirement (raised from one to four during the first five trials of pretraining), the trial terminated with 4 sec access to grain. Otherwise the trial ended, with reinforcement, after 8 sec. During the 12 discrimination training sessions which followed, both positive and negative trials were presented. Forty reinforced, or S+, trials were randomly intermixed with 40 nonreinforced, or S—, trials. For all Ss, S+ consisted of light plus tone, designated TL1. There were three different experimental groups differing only with respect to the stimuli on negative trials. For Group TL1-L1 (N = 5) noise and L1 were presented. In Group TL1-TD (N = 6) it was tone and a dark key. For Group TL1-D (N = 6) S— was noise and a dark key.

Tests for stimulus control were given after discrimination training. Four test sessions were run on successive days. Tests were made at four points along a generalization gradient based on decreasing intensities of the key-light; the four light levels designated L1, L2, L4, and L5 were presented. At each light level trials were presented with and without tone, yielding a total of eight different stimuli which were presented in 10 independent random orders making a total of 80 presentations in a session. Except for

A demonstration of overshadowing in operant conditioning^{1,2}

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Seventeen pigeons were trained on a go/no-go discrimination with tone and light as positive trial stimuli. Negative trials for three different groups were: (a) light and noise, (b) tone and a dark key, and (c) a dark key and noise. Stimulus control tests in extinction consisted of presenting four different brightness levels of the key-light presented with and without tone. The results showed that, for the pigeon, light overshadows tone.

When two stimulus features are presented to an animal in a compound they may not both become strongly associated with a reinforced response made in the presence of that compound. In the extreme case, only one of the stimuli may become associated to the complete exclusion of the other. Pavlov (1927) demonstrated this phenomenon using dogs as Ss. His procedure was to

condition responding in the presence of two stimuli and then present the two elements alone. When responding to one element was equal to the response elicited by the compound and the second element showed little or no evidence of conditioning, the strongly conditioned element was said to have "overshadowed" the element which did not condition. Independent evidence indicated that had the weaker element been presented alone, conditioning would have taken place.

There is some evidence for overshadowing in operant discrimination learning. One demonstration is an experiment by Newman & Baron (1965). They found that pigeons trained to peck at a white line on a green background as S+ and a red key as S— showed no control by line tilt. When S— was a green key good control by line tilt occurred. The difference in color overshadowed line tilt. The present experiment used a discriminated trial procedure (Jenkins, 1962) and measured control by