Effects of partial vs consistent reward in noncontingent pairings of stimuli with reward: A noncontingently produced positive contrast effect*

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Rats received pairings of two stimuli with reward noncontingently in the Skinner box. During noncontingent pairings, the bar was immobilized. For Group CC 100% of the presentations of both stimuli were rewarded (S_1+ , S_2+), for Group PP 50% of the presentations of each stimulus were rewarded (S_1+ , S_2+), and for Group PC one stimulus was followed by reward on 50% of its presentations, while the second stimulus was followed by reward on 100% of its presentations (S_1+ , S_2+). A fourth group received the stimuli and reward nonpaired. In a subsequent rewarded test phase, the response facilitating effects of the stimuli were evaluated. In the test phase all groups that received reward paired with S_1 and S_2 performed better in the presence of S_1 and S_2 than the group for which the stimuli were not paired with reward. For groups that received the stimuli paired with reward, a difference due to schedule of reward occurred when schedule of reward was varied within Ss (Group PC), but not when varied between Ss (Group PP vs Group CC). The specific form of this finding was that Group PC's performance in the presence of S_2+ was more vigorous than its performance in the presence of S_1+ and was more vigorous than the performance of Groups PP and CC to S_2 . Group PC's performance to S_1+ did not differ from that of Groups PP and CC to S_1 .

Recently interest has developed in the effects of pairing the offset of stimuli with reward noncontingently, i.e., regardless of the animal's behavior. Customarily, during the noncontingent phase the animal is prevented from making the test response, e.g., in a Skinner box the bar may be immobilized during the noncontingent phase. One question of concern has been whether presentation of a stimulus that has been paired noncontingently with reward on 100% of its presentations ($S+$) will affect the vigor of the test response when presented before the response. It has been shown that performance of a previously learned response (Hyde, Trapold, & Gross, 1969), as well as acquisition of a new response (Trapold & Winokur, 1967), is more vigorous if an $S+$ is presented rather than a stimulus that has not been paired with reward.

The present experiment compared the facilitative effects of a stimulus that has been paired noncontingently with reward on 50% of its presentations ($S\pm$) with the facilitative effects of a stimulus that has been paired with reward on 100% of its presentations ($S+$). It might be expected on a number of grounds that responding in the test phase would differ in the presence of an $S\pm$ and an $S+$, although which stimulus will produce greater response facilitation is not clear. For example, within anticipatory response theory, which has often been applied to data from noncontingent pairing studies, it is possible to predict greater response facilitation in the presence of either an $S\pm$ or an $S+$. If it

is assumed that the anticipatory goal response, r_g-S_g , is less strongly conditioned when a stimulus is partially rewarded rather than consistently rewarded, it would be predicted that an $S\pm$ would produce less response facilitation than an $S+$. Alternatively, if it is assumed that an anticipatory frustration reaction, r_f-S_f , is conditioned when a stimulus is partially rewarded, it might be predicted that an $S\pm$ would produce greater response facilitation in the test phase than an $S+$. In the test phase in the present experiment and in previous experiments, a barpress turned off the test stimulus; thus, responding in the presence of an $S\pm$ could be reinforced by frustration reduction (e.g., Daly & McCroskery, 1973).

In the present study all experimental groups received two different stimuli during noncontingent pairings. For Group PC one stimulus was followed by reward on 50% of its presentations ($S_1\pm$), while the other stimulus was followed by reward on 100% of its presentations (S_2+). Group PP received $S_1\pm S_2\pm$ training, while Group CC received S_1+S_2+ training. Number of rewarded pairings was equated rather than number of stimulus presentations; thus, an $S\pm$ was paired with reward the same number of times as an $S+$, but an $S\pm$ was presented more frequently. A fourth group (Group NP) received the stimuli and reward, but the stimuli were never paired with reward.

METHOD

Subjects

The Ss were 24 naive male albino rats approximately 90 days old upon arrival from the Holtzman Company, Madison, Wisconsin.

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Apparatus

The apparatus consisted of two identical Scientific Prototype A-110/D700 rodent test cages that had been modified to permit the use of automatic programming equipment. Each test cage was additionally equipped with a 2900-cps tone source and a Western Electric buzzer. The test cages were enclosed within separate sound-insulated boxes. Each box was illuminated by a 7½-W incandescent light source. Water was continuously available to Ss in the test cage throughout the course of the experiment.

Procedure

Following arrival in the laboratory, Ss were fed ad lib for 6 days and were assigned to four groups matched on weight on the sixth day. On this day (Day 1), a 12-g/day deprivation schedule began and continued throughout the experiment. When the rats received food in training, the amount received was subtracted from their daily ration, the remainder of their daily ration being fed 30 min following return to the home cage. The experiment may be divided into five phases: preliminary training, free operant training, noncontingent pairing, discriminative operant training, and testing. All groups were treated identically in all phases except noncontingent pairing.

Preliminary Training

On Days 13-15 the rats were handled individually for 90 sec. On each of Days 16 and 17, each S was placed in the apparatus for 10 min with the bars immobilized. Twelve .045-g Noyes pellets were delivered singly on a VI 30-sec schedule to each S on Days 18-21.

Free Operant Training

On Days 22-27 each S was reinforced with a single .045-g pellet for each barpress, for a total of 15 reinforcements each day.

Noncontingent Pairings

During this phase (Days 28-44), the response bars were again immobilized. Ss were given 3-sec randomly intermixed presentations of the tone stimulus alone and buzzer stimulus alone on a VI 30-sec schedule, with the restriction that a minimum of 9 sec intervene between stimulus presentations. Whether the tone or the buzzer was S_1 or S_2 was counterbalanced across Ss within each group. On reinforced presentations a single .045-g pellet was delivered immediately following termination of the stimulus. Each day Group PP received 12 presentations of each of S_1 and S_2 . Both stimuli were followed on a random 50% schedule by delivery of reinforcement. Each day Group PC received 12 presentations of S_1 reinforced on a random 50% schedule and 6 reinforced presentations of S_2 . Each day Group CC received six reinforced presentations of each of S_1 and S_2 . Group NP received 12 presentations each of S_1 and S_2 , as well as 12 reinforcements, but the delivery of reinforcement was unsystematic with respect to the presentation of the stimuli with the restriction that a minimum of 9 sec intervene between any two events (stimuli or reinforcements).

Discriminative Operant Training

On Days 45-54 the response bars were again made operational. The onset of the cue light located directly above the response bar signaled the availability of reinforcement. The first response following the onset of the cue light terminated the light and resulted in delivery of one .045-g pellet. The time intervening between onset of the cue light and the S's response was recorded

as response latency. Twelve trials were given each day. The intertrial interval was VI 30 sec, with a minimum of 9 sec imposed between trials. If the S produced an uncued response in the 3 sec immediately preceding the beginning of a trial, the start of that trial was delayed for an additional 3 sec. This procedure resulted in a rapid decline in the number of spontaneous responses.

Test Phase

On Days 55-68 the procedure was identical to discriminative operant training, except that on Trials 6 and 12 of each day onset of the cue light was replaced by onset of either S_1 or S_2 . The order of presentation of S_1 and S_2 was counterbalanced for each S, half of the Ss in each group beginning with S_1 ($S_1 S_2 S_1$, etc.) and half of the Ss beginning with S_2 .

RESULTS

The groups did not differ in performance in any phase until the test phase. In free operant acquisition, the time necessary for each S to complete 15 reinforced presses each day was recorded. Analysis of these data indicated that the groups did not differ ($F < 1$). Mean latencies for each day in discriminative operant training were converted to logs. Analysis of these data indicated that the groups did not differ [$F(3,20) = 1.48, p > .20$].

In the test phase two test trials, one with S_1 and one with S_2 , were given each day on Trials 6 and 12. On the remainder of the trials, the light stimulus (SD) used in discriminative operant training was presented. Mean latencies over 2 days for each type of stimulus presentation (S_1 , S_2 , or SD) were converted to logs. The data on SD trials were analyzed in a 4 (groups) by 7 (trial blocks) analysis of variance, and the data on test trials were analyzed in a 4 (groups) by 2 (S_1 vs S_2) by 7 (trial blocks) analysis of variance. Initially, analyses including tone vs buzzer as an additional factor were performed. However, the difference due to which stimulus was a tone or buzzer was not significant in any analysis, nor was any interaction involving tone vs buzzer significant. Thus, this factor was excluded from the analyses.

Although there was a tendency for groups receiving partial reward in the presence of at least one stimulus (Groups PP and PC) to respond faster on SD trials than Group CC, the groups did not differ significantly on SD trials [$F(3,16) = 1.51, p > .20$], nor did the relationship among groups change over trial blocks (Trial Blocks by Groups, $F < 1$).

Analyses of the data from test trials indicated that the difference due to trial blocks was significant [$F(6,120) = 14.14, p < .001$]. Initially in the test phase, presentation of S_1 and S_2 produced relatively long latencies, presumably due to stimulus generalization decrement, as on S_1 and S_2 test trials the normal discriminative operant stimulus, SD , was not presented. This effect became smaller over trial blocks, producing the significant trial blocks effect. However, no interaction involving trial blocks approached significance; thus, the data are presented in Fig. 1 summed over trial blocks.

Figure 1 shows the mean over all of the test phase of the mean log latencies for each group on S_1 and S_2 trials. As may be seen in Fig. 1, groups that had S_1 and S_2 paired with reward responded faster when S_1 or S_2 was presented than did Group NP. Concerning the three groups that received reward paired with S_1 and S_2 , it may be seen that the main difference between and within groups is that Group PC responded faster to S_2 than it did to S_1 . Groups PP and CC responded nondifferentially to S_1 and S_2 , their performance to both stimuli being about at the level of Group PC's performance to S_1 .

Results of the analyses of variance described above supported these impressions. In the test phase the groups differed significantly [$F(3,20) = 10.26, p < .001$]. The difference due to type of stimulus presented was not significant ($F < 1$); however, the Groups by Type of Stimulus Presented interaction was significant [$F(3,20) = 8.98, p < .001$]. This interaction was broken down to compare pairs of experimental groups in performance to S_1 and S_2 . The Group PP vs Group CC by S_1 vs S_2 interaction was not significant ($F < 1$). However, both interactions involving Group PC were significant: Group PC vs Group PP by S_1 vs S_2 [$F(1,10) = 12.64, p < .01$]; Group PC vs Group CC by S_1 vs S_2 [$F(1,10) = 12.87, p < .01$]. Analysis of data on S_1 trials only indicated that the groups differed significantly. Subsequent Newman-Keuls tests ($p < .05$) indicated that Group NP was slower when S_1 was presented than the other three groups, which did not differ. On S_2 test trials the groups also differed significantly [$F(3,20) = 13.82, p < .001$]. Subsequent Newman-Keuls tests indicated that Group NP was slower when S_2 was presented than the other three groups. In addition, Group PC responded significantly faster when S_2 was presented than Group PP or Group CC, which did not differ from each other. Each experimental group's performance on the two types of test trials was also analyzed in a within-Ss analysis of variance. Groups PP and CC did not respond differentially to S_1 and S_2 [Group PP: $F(1,5) = 1.41, p > .20$; Group CC: $F(1,5) = 2.02, p > .20$], while Group PC responded significantly faster when S_2 was presented rather than S_1 [$F(1,5) = 12.41, p < .02$].

DISCUSSION

The major finding obtained here was that a difference in the response facilitating effects of an $S^\pm$ and an $S^\mp$ occurred only for Group PC. Group PC responded more vigorously to $S_2^\pm$ than to $S_1^\pm$. However, Groups PP and CC responded equivalently to S_1 and to S_2 despite the fact that these stimuli were both $S^\pm$ for Group PP and were both $S^\mp$ for Group CC. Also, Group PC's performance to $S_2^\pm$ was superior to that of Group CC to either $S_1^\pm$ or $S_2^\pm$, while Group PC's performance to $S_1^\pm$ did not differ from that of Group PP to $S_1^\pm$ or $S_2^\pm$. Thus, Group PC's performance was not reduced to $S_1^\pm$

Fig. 1. Mean log mean latency for the four groups over all of the test phase in the presence of the test stimuli.

but rather was facilitated to $S_2^\pm$. This phenomenon is similar to positive contrast effects obtained in the Skinner box when an organism receives two schedules of reward correlated with two stimuli during instrumental training (e.g., Reynolds, 1961). However, in the typical behavioral contrast study, the schedules of reward are correlated with the stimuli during instrumental training, while here the schedules of reward were correlated with the stimuli prior to instrumental training. Also, in the typical behavioral contrast study, negative contrast effects are obtained in addition to positive contrast effects (e.g., Reynolds, 1961). Thus, whether similar processes are operating here and in the typical behavioral contrast study is not clear. It may be appropriate, nevertheless, to term the phenomenon obtained here a noncontingently produced positive contrast effect.

It does not seem possible to account for the present results on the basis of number of stimulus presentations. Groups that received different numbers of stimulus presentations performed equivalently (Group PP vs Group CC), while groups that received the same number of presentations of a given stimulus performed differently in the presence of that stimulus under some conditions (Group PC vs Group CC to S_2) and equivalently under other conditions (Group PC vs Group PP to S_1).

These results are also not easily explicable within current theories. As pointed out above, within anticipatory response theory it might be expected that an $S_{\pm}$ would produce less or more response facilitation than an $S_{\mp}$. An $S_{\pm}$ produced less response facilitation than an $S_{\mp}$ for Group PC, which can be explained by assuming that conditioning of r_g would be weaker to $S_1 \pm$ than to $S_2 \mp$. However, if this were assumed, it would also be expected that Group PP would have been inferior to Group CC in performance to S_1 and S_2 , and these groups did not differ here. It would also seem within anticipatory response theory that $S_{\pm}$ training would affect performance to the stimulus that received the $S_{\pm}$ training. However, Group PC did not differ from Group PP in performance to $S_1 \pm$ but did differ from Group CC in performance to $S_2 \mp$.

A number of theories suggest that the correlation of a stimulus with reward will affect the association value accrued to that stimulus and other stimuli in the situation (e.g., Rescorla & Wagner, 1972; Sutherland & Mackintosh, 1971). It is doubtful, however, that the present results are relevant to these views. These views are most directly relevant to the situation in which two or more cues are presented in compound, with one cue being a more valid predictor of reward than the other cues. In the present experiment, the predictive validity of S_1 and S_2 was varied both between and within groups, but S_1 and S_2 were never presented in compound. It is true, however, that background stimuli were presented in compound with both S_1 and S_2 . However, if background stimuli are taken into account, it would seem that Group PP should have been inferior to Group CC in the presence of both S_1 and S_2 and Group PC should have been inferior to Group PP in performance to S_1 . Relative to the background cues, S_1 and S_2 were both more valid predictors of reward for Group CC than for Group PP, and S_1 was a less valid predictor of reward for Group PC than it was for Group PP. Yet Group PP and Group CC did not differ, and Groups PC and PP responded equivalently to S_1 . It is possible, however, that the present experimental situation was not sensitive enough to measure a

difference between Groups PP and CC and between Group PC and Group PP to S_1 .

The following two conclusions are suggested by the present results. First, variations in schedule of reward during noncontingent pairings produce greater effects when varied within Ss than when varied between Ss. And second, pairing a given stimulus noncontingently with partial reward rather than consistent reward does not seem to affect performance to that stimulus (Group PP did not differ from Group CC and Group PC did not differ from either of these groups in performance to $S_1 \pm$). Rather, in the within-Ss condition, pairing a given stimulus with partial reward facilitates performance to a second stimulus that has been paired with consistent reward (Group PC was superior to Group CC in performance to $S_2 \mp$).

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