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Stimulus facilitation of delayed-reward performance as a function of the cue's spatial position

ROGER M. TARPY and FREDERICK L. SAWABINI
Bucknell University, Lewisburg, Pennsylvania 17837

Rats were given 30 shock escape trials with a 3-sec delay of shock offset. A light cue presented during the delay facilitated performance significantly more when the light was located over the lever as opposed to being located on the opposite wall. It was concluded that orientation, in part, plays a significant role in determining the extent to which cues facilitate delayed-reward performance.

Performance for a delayed reward is greatly facilitated when a secondary cue is presented during the delay interval (see Tarpy & Sawabini, 1974, for a review). Several hypotheses have been offered to explain the facilitation effect, the most compelling of which is the secondary reinforcement hypothesis. According to this position, cues that occur during the delay interval become secondary reinforcers due to their contiguity with reward; they facilitate performance by providing immediate reinforcement in the temporary absence of primary reward (i.e., during the delay interval).

Although certain problems have been noted (e.g., see Tarpy & Sawabini, 1974), evidence for the secondary reinforcement hypothesis is fairly extensive. For example, presentation of cues during extinction prolongs responding (Tombaugh & Tombaugh, 1969). In addition, delay cues occurring just prior to reward (therefore maximizing secondary reinforcement strength–Jenkins, 1950) facilitate acquisition (Tombaugh & Tombaugh, 1971) more effectively than delay cues which occur immediately after the response.

In addition to providing secondary reward, delay cues might also facilitate performance by eliciting orientation to the response and/or goal locus. More specifically, unconditioned attention or orientation, elicited by the delay cues, would, if physically compatible with the criterion response, inhibit the formation of competing responses and thus facilitate performance. Such an orientation hypothesis is consistent with Spence's (1956) competing response theory. Spence noted in his book that restriction of the apparatus size (Carleton study) compelled the subject to maintain orientation to the foodcup and that the presence of secondary cues such as the foodcup (Harker & Shilling studies) enhanced orientation during the delay interval. In both of these cases, instrumental performance was maintained at a relatively high level even when the delay interval was increased.

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The present study attempted to investigate further the orientation hypothesis by varying the spatial location of the delay cue. The orientation hypothesis would predict that facilitation of performance would depend, in part, upon the cue's spatial location since orientation to the cue in one position (e.g., near the response locus) would be physically more compatible with the criterion response than orientation to the cue at a more distant location. In contrast, the secondary reinforcement hypothesis would not predict large differences in facilitation due to the cue's spatial location, assuming, of course, that the cue was noticeable at either position.

METHOD

Subjects

The subjects were 30 Sprague-Dawley rats weighing between 210 and 340 g. The animals were housed in pairs and were given free access to food and water. There were seven females and three males in each of the three groups of subjects.

Apparatus

The apparatus was the same as used by Tarpy and Koster (1970). Briefly, it consisted of a lever box with a hinged plastic top. The grid floor was constructed from 1/8-in. stainless steel rods spaced ½ in. apart. A 200-V ac shock (Campbell & Teghtsoonian, 1958), scrambled four times per second, was used. A 24-V dc pilot light was located 5½ in. directly above the lever; a second light was located on the opposite wall at the same height. The lever box was housed in a lightproof/sound-attenuating chamber.

Procedure

Following a 1-min habituation period, all subjects were given 30 escape trials (with a 45-sec intertrial interval). On each trial, shock could be terminated by a leverpress; the shock offset, however, was delayed for 3 sec. Three groups of subjects were used: The control group (NC) did not receive the light cue during the delay interval while the two experimental groups did receive a light. For one of the groups (C-bar), the light over the lever was illuminated during the delay interval, whereas for the other group (C-opp) the light on the opposite wall was illuminated during the delay interval. The latency to respond on each trial (from the onset of shock to the leverpress) and the total number of intertrial and intradelay responses were recorded for each subject.

RESULTS

Each response latency was converted into a reciprocal speed score; the scores then were averaged over a block of six trials. Group mean speed per block of six trials is shown in Figure 1. An analysis of variance indicated a significant groups effect [$F(2,26) = 7.3$, $p < .005$] and trials effect [$F(4,107) = 3.7$, $p < .01$]. The interaction, however, was not significant. Individual group comparisons confirmed that the subjects in Group C-bar performed significantly faster than those in Groups C-opp and NC. Although these latter two groups did not differ from each other overall [$F(1,18) = 2.7$, $p > .1$], significant differences were obtained for the last two trial blocks ($p < .025$, U test).

The mean number of intertrial responses for each group was: C-bar = 32.4, C-opp = 23.2, and NC = 20.3. Analysis failed to show significant group differences although the NC and C-bar comparison was nearly significant ($.1 > p > .05$). The mean number of intradelay responses for each group was 63.1 (C-bar), 67.2 (C-opp), and 62.7 (NC). These differences were not statistically significant, supporting the previous contention by Tarpy and Koster (1970) that stimulus facilitation of delayed-reward learning is unrelated to intradelay responding.

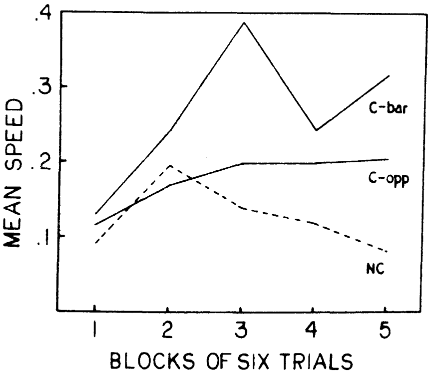

Figure 1. Mean speed (reciprocal latency) as a function of five blocks of six trials for the three groups.

DISCUSSION

The findings of this study clearly indicate that facilitation of delayed-reward performance by a secondary cue is markedly influenced by the spatial location of the cue. Specifically, subjects in Group C-bar performed reliably faster than those in the other two groups. According to the orientation hypothesis, the light located above the lever facilitated performance in Group C-bar because it elicited an unconditioned orienting or attending response. This response functioned to keep the subject near the lever thereby increasing the probability of making a speedy criterion response on the next trial. In contrast, the light on the opposite wall did not facilitate escape performance for the C-opp subjects. According to the present theory, orientation or attention of the C-opp subjects during the delay interval was not directed toward the response locus. Therefore, the probability that the subjects would be near the lever at the start of the next trial (i.e., execute a speedy response) was reduced. Indeed, mean total intertrial responses for the C-opp subjects was nearly the same as for the NC subjects whereas the C-bar mean was higher. Although not significant, these differences suggest that C-bar subjects remained closer to (oriented more toward) the lever following shock offset than subjects in Groups C-opp and NC thus increasing the probability of executing an intertrial response.

The secondary reinforcement hypothesis would not predict the differential results found in this study unless the cue on the opposite wall was not noticeable or the cues, as secondary reinforcers, simply elicited approach behavior.

There can be little doubt that the opposite-wall cue was perceived by the C-opp subjects; the general level of illumination increased markedly when *either* light was turned on. More important, mean C-opp performance was faster than NC responding on the last two trial blocks, suggesting that some facilitation of behavior was occurring in the C-opp group. Clearly, such differences would not occur if the light had not been perceived by the subjects.

Regarding the second point, the proponents of the secondary reinforcement hypothesis could argue that the cues were secondary rewards that merely elicited approach behavior (thus decreasing the probability of the C-opp subjects making a speedy lever response on the next trial). This counterargument, however, is not supported by the present data—subjects in Group C-opp were faster on the last two training blocks than those in Group NC. If this counterargument was valid, one would certainly predict that the C-opp subjects would be explicitly drawn away from the lever compared to the NC subjects resulting in significantly *slower* performance.

Although the present data do not discount entirely the secondary reinforcement hypothesis, they do suggest that approach behavior is not a necessary or essential response to secondary rewards. In addition, the data highlight the importance of unconditioned orientation in the facilitation of delayed-reward performance. The task of specifying further the role or orientation within the context of other explanatory systems (e.g., secondary reinforcement, information, etc.), of course, remains.

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