A "partial reinforcement-extinction effect" in a perceptual-motor task

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The resemblance of the effects "knowledge of results" (KR) in perceptual-motor skills learning and those of reward or reinforcement in instrumental conditioning have long been noted. In the present study, an attempt was made to determine if intermittent on partial KR (PKR) enhanced "resistance to extinction" (RE) in a manner similar to the partial-reinforcement effect (PRE) in instrumental conditioning. Results indicated that PKR during the initial trials on a rotary-pursuit task did significantly enhance the "willingness" of Ss to continue to perform on that task as opposed to Ss who received initial, consistent KR. This result was interpreted as analogous to the PRE in instrumental conditioning.

In a 1961 review, Bilodeau and Bilodeau commented that "studies of feedback or knowledge of results (KR) show it to be the strongest, most important variable controlling performance and learning. It has been shown . . . that there is no improvement without KR, progressive improvement with it, and a deterioration after its withdrawal." The parallel between these functions of KR in motor-skills learning and those of reward or reinforcement in instrumental conditioning is obvious and striking. Thus, in conditioning, if an R is followed by reward it tends to be strengthened or acquired, while the failure to present reward leads to the progressive weakening or extinction of that R. This similarity between the effects of KR and reinforcement has led some observers to suggest that these variables may influence performance through the same or similar mechanisms. Thus, Brown (1949) argued that KR might affect performance in at least three ways: provide information or cue functions, add to S's level of motivation, and directly reward or strengthen S's response. These potential functions of KR have, however, proven to be quite difficult to distinguish experimentally.

The present study represented an attempt to explore further the similarities between the effects of KR in perceptual-motor learning and those of reinforcement in instrumental

conditioning. Thus, in the latter case, it is well known that intermittent or partial reinforcement (PR) leads to greater resistance to extinction (RE) than does consistent reinforcement (CR) during acquisition. For example, rats trained to bar-press in a Skinner box on a PR schedule typically continue to respond following cessation of reward (extinction) for a substantially longer period of time, or greater number of Rs, than do Ss trained on a CR schedule.

In the present experiment, an attempt was made to determine if human Ss trained on a schedule of intermittent or partial KR (PKR) on a perceptual-motor task would show greater "RE" in that task than would Ss trained with consistent KR (CKR). Specifically, college students were trained in a situation in which they were instructed to terminate the experiment whenever they "became bored" or "lost interest." The independent variable was the schedule (50% or 100%) KR¹ (time-on-target) that the Ss received during an initial series of trials after which no further KR was given. The dependent variable was the number of trials that Ss remained in the experiment (i.e., continued to perform) following termination of KR. If KR and reinforcement operate in a similar manner, then the initial block of trials might be considered the "acquisition" phase of the experiment conducted under either partial or consistent "reinforcement." The subsequent phase, in which no further KR was given, might be considered the "extinction" phase, with the number of additional trials that S remained in the experiment serving as the measure of "RE." The expectation was, of course, that "RE" following PKR would be greater than that following CKR.

METHOD

The Ss were 51 student volunteers from the introductory psychology course at the University of South Carolina. The apparatus was a Marietta 5-6S pursuit rotor, Model D, which was equipped with automatic timers for both "test" and "rest" intervals and a clock that measured time-on-target in .01-sec units. The turntable was 12 in. in diam, while the target circle was 0.75 in. in diam. The turntable revolved at 60 rpm.

When the S arrived at the experimental room, E read instructions describing the pursuit rotor and S's task. The S was also instructed that each test trial would last 10 sec, and that on some, but not all, of

the trials he would be informed of the amount of time he had stayed in contact with the target circle. Finally, part of the instructions stated: "It is extremely important that you maintain interest throughout the experiment. If you lose interest, or if the task gets boring, or if you become tired and wish to stop, please tell me and the experiment is over. You will do this experiment a disservice if you continue in it beyond the point when you wish to stop. Remember, the experiment is over as soon as you want it to be." After these instructions were read, the pursuit rotor was activated to provide an alternating series of 10-sec test periods and 12-sec rest periods. Throughout the experiment, S stood in front of the pursuit rotor opposite E who sat at the table on which the apparatus was placed and recorded S's time-on-target score on each trial.

The Ss were assigned randomly to three groups of 17 Ss each, with the restriction that the ratio of males to females in each group be the same. In Group CKR, Ss were correctly informed on their time-on-target for each of the first 20 trials. Thereafter, they were given no further KR. For Ss in Group PKR, half of the first 20 trials were randomly designated "KR trials" and only on these 10 trials was S informed of his time-on-target. The Ss in the third group—the "control group"—were informed of their time-on-target on each trial throughout the experiment. For Ss in each group, testing was terminated whenever the S indicated that he wished it to be, and the total number of trials on which that S performed was recorded.

RESULTS

The total number of trials that each S remained in the experiment before asking that it be terminated was considered that S's measure of "resistance to extinction (RE)." For Group CKR, the mean number of trials was 110.5, while for Group PKR, it was 169.6. Thus, Ss in Group PKR remained in the experiment for an average of 59.1 trials (or about 21.8 min) longer than did Ss in Group CKR. On the other hand, the control group's Ss continued to perform for a mean of 189.7 trials—i.e., longer than either of the experimental groups for which KR was discontinued at the end of the initial 20 trials.

A simple analysis of variance performed on these "RE scores" indicated that the group differences were reliable ($F = 4.10$, $df = 2/48$, $p < .05$). A comparison of the means of Groups CKR and PKR indicated a significant superiority of the latter ($t = 2.25$, $df = 32$, $p < .05$). Similarly, the control group was reliably superior to Group PKR in terms of the "RE scores" ($t = 2.75$, $df = 32$, $p < .01$).

An analysis of "accuracy of performance" (i.e., time on target) was also performed, using each S's mean time-on-target on all trials following the initial 20 as the measure of accuracy. The means for these scores were 4.03 sec for Group CKR, 4.15 sec for Group PKR, and 6.01 sec for the control group. While the overall group differences in accuracy did prove significant ($F = 4.26$, $df = 2/48$, $p < .05$), the experimental groups, PKR and CKR, differed neither appreciably nor reliably ($t = 0.49$). Thus, the obtained difference in accuracy was attributable to the superiority of the control group.

DISCUSSION

The hypothesis of primary concern in the present investigation was that KR in perceptual-motor learning affects performance in much the same manner as does reinforcement in instrumental conditioning. Since it is well known that PR during the acquisition of an instrumental R leads to greater RE for that R than does CR, it was expected that PKR during the "acquisition" of a pursuit-rotor tracking R would also lead to greater "RE" for that R following discontinuance of KR than would CKR during "acquisition." Moreover, since Ss in the control group received KR (i.e., "reinforcement") on every trial of the experiment, it was expected that this group should continue to perform longer than either of the experimental groups for which KR was discontinued following the initial 20 trials. Both of these expectations were confirmed and, thus, an additional similarity between the effects of reinforcement and KR seemed to have been demonstrated.

Although the present study did appear to reveal an effect of PKR similar to the partial-reinforcement effect (PRE) in instrumental conditioning, it did not provide a definitive basis for concluding that the mechanisms underlying these effects are necessarily identical. In this connection, it is interesting to note that the two interpretations of PRE in instrumental conditioning that are currently most popular are the "frustration theory" (e.g., Amsel, 1958; Spence, 1960) and the "sequential" or "aftereffects" hypothesis (e.g., Capaldi, 1967). According to the frustration hypothesis, the occurrence of the nonreinforcement of a R that has frequently been followed by reward results in a "frustration R" that, in turn, produces cues that evoke other overt Rs that tend to interfere with the instrumental R. When Ss are trained on a schedule of PR, however, these "frustration-produced cues" eventually come to be conditioned stimuli for the instrumental R and, hence, no longer interfere with it. Thus, during extinction,

when all trials are nonreinforced, Ss originally trained on PR are expected to continue to perform the instrumental R longer than the Ss originally trained under CR and who, therefore, have never previously been exposed to nonreinforcement. If the failure to provide KR (time-on-target) can be considered a "frustrating event" in perceptual-motor learning, then the superiority of Group PKR to Group CKR in the present experiment might be interpreted in similar terms.

According to Capaldi's "sequential interpretation" of the PRE, reinforced and nonreinforced trials are assumed to result in stimulus aftereffects that are discriminably different. Those Ss who are initially trained on a schedule of random PR are assumed to become conditioned to performing the instrumental R in the presence of the aftereffects of both reinforced and nonreinforced trials, while Ss trained on CR learn to perform the instrumental R only in the presence of the aftereffects of reinforced trials. Thus, during extinction, when all trials other than the first are conducted in the presence of the aftereffects of nonreinforcement, Ss initially trained with PR are expected to perform at a higher level than are those trained initially with CR, i.e., due to generalization decrement, etc. If it is assumed that those trials on which KR was administered in the present experiment result in aftereffects that were discriminably different from the aftereffects present following trials on which KR was omitted, then Capaldi's analysis would also seem to predict greater "RE" for Group PKR than for Group CKR, since the former would presumably have learned to continue to perform in the presence of the aftereffects of "no-KR." In short, either the "frustration" or the "sequential" hypothesis could presumably predict these results.

With respect to the accuracy of target-tracking performance, no difference was obtained between Groups CKR and PKR. On the other hand, the control group that received KR on all trials was superior in accuracy to either of the experimental groups. This superiority of the control group in accuracy should be interpreted cautiously, however, since (1) the analysis was based on overall mean time-on-target, (2) accuracy improved with amount of practice for Ss in each group, and (3) the control group continued to perform longer than either of the experimental groups. Thus, it is possible that the superior performance (accuracy) of the control group may simply have reflected their greater amount of practice. On the other

hand, there was no significant difference in the mean accuracy of Groups PKR and CKR, although the former continued to perform for a reliably larger number of trials. Thus, the confounding of "RE" with accuracy of performance may not have accounted for the superiority in accuracy of the control group. Finally, there seems, to the writers, to be no clear theoretical basis for predicting the accuracy of "extinction" performance following PKR vs CKR, even though it would seem apparent that this measure should be related to the KR schedule employed during "acquisition."

In summary, the present experiment suggested that the similarity between KR and reinforcement extends also to the schedule on which the two events are administered—i.e., in both cases, intermittent schedules during "acquisition" appear to enhance "RE." It might be noted that the apparent effectiveness of knowledge of time-on-target with the pursuit-rotor is rather surprising in view of the considerable "KR" that this task inherently provides. Nevertheless, other studies from our laboratories have indicated even further parallels between reinforcement or reward in instrumental conditioning and KR with the pursuit-rotor. For example, it appeared that "RE" in this task is an inverse function of the per cent KR during acquisition (Mandell, 1969). Similarly, it appears that shifts in the percentage of the trials in which KR is administered result in levels of "RE" analogous to those obtained following shifts in per cent reinforcement in instrumental conditioning (Elstad, 1967). Finally, downward shifts in the E-determined "quality" of KR (i.e., "good" to "bad"; May, 1968) seem to result in "negative-contrast effects" in performance on the pursuit-rotor similar to those obtained following reduction of magnitude of reward in instrumental conditioning (Black, 1967, 1968).

REFERENCES

- AMSEL, A. The role of frustrative nonreward in noncontinuous reward situations. *Psychological Bulletin*, 1958, 55, 102-119.
- BILODEAU, E. A., & BILODEAU, I. M. Motor skills learning. *Annual Review of Psychology*, 1961, 12, 243-280.
- BLACK, P. E. An analogue to resistance to extinction in perceptual-motor learning. Paper presented at the meeting of the Psychonomic Society, Chicago, 1967.
- BLACK, R. W. Shifts in magnitude of reward and contrast effects in instrumental and selective learning: A reinterpretation. *Psychological Review*, 1968, 75, 114-126.
- BROWN, J. S. A proposed program of research on psychological feedback (knowledge of results) in the performance of psychomotor tasks. U.S. Human Resources Research Center, Conference Report No. 49-2 (1949).

- CAPALDI, E. J. A sequential hypothesis of instrumental learning. In Spence, K. W. and Spence, J. T. (Eds.), *The psychology of learning and motivation*, Vol. 1. New York: Academic Press, 1967.
- ELSTAD, PATRICIA. Shifts in per cent reinforcement and resistance to extinction in instrumental reward conditioning. Ph.D. dissertation, University of Iowa, 1966.
- MANDELL, E. "Resistance to extinction" of a pursuit-rotor tracking response as a function of prior schedule of knowledge of results. Doctoral dissertation, University of South Carolina, 1969.
- MAY, J. Effects of shifts in experimenter-determined "knowledge of results" and an analogue of resistance to extinction of a perceptual-motor response. Master's thesis, University of South Carolina, 1968.

SPENCE, K. W. *Behavior theory and learning*. Englewood Cliffs, N.J.: Prentice-Hall, 1960.

NOTE

1. The expression "knowledge of results" (KR), as used in this paper, is more correctly referred to as "augmented knowledge of results." The pursuit-rotor task inherently provides S with considerable knowledge of his performance, since S could directly observe visually the contact of the stylus with the target as well as hear the closure of a relay whenever the stylus made contact with the target. Thus, informing S of his time-on-target only "augmented" this KR. Nevertheless, for simplicity of description, the E's statement to S of his time-on-target is referred to as "KR" for the purpose of this paper.

secret information should be a stronger reinforcer than freely communicable information, because the secret information is more valued.

SUBJECTS AND DESIGN

The Ss were 90 female undergraduates. There were two experimental groups and three control groups, with 18 Ss in each group. Both experimental groups received the same information as reinforcement, one with secrecy instructions and one without. All three control groups made the response but were not reinforced. There was a no-information control group. Two other control groups were included against the possibility that the secrecy instructions or highly interesting information could facilitate performance by some means other than reinforcing that performance. In these two (one secret, one open) control groups, the Ss were exposed to the information, but the information was not used as a reinforcer. The information preceded, rather than followed, the instrumental response. Since presentation of the information was not contingent upon the S's making the instrumental response, any information effects in these control groups would not be due to reinforcement of the instrumental response.

REINFORCERS

A boundary condition of Brock's commodity theory states that "when prospective recipients are uninterested in particular information, commodity propositions are inapplicable [Brock, 1968, p. 271]." It was, therefore, necessary to develop an informational reinforcer that met this boundary condition unambiguously and that could plausibly be made secret. The reinforcer chosen was information concerning (favorable) personality traits ostensibly measured by a psychological test. Previous experiences with Ss, and informal interviews following this experiment, indicate that Ss are very much interested in receiving information about their personalities.

The information was made secret for the secret groups by telling them that the information was highly confidential and that: (1) disclosure could ruin future research because "if a person reads into the analyzer knowing which traits are being measured, his preconceived ideas will spoil the test"; and (2) only Ss who scored in the top 20% on a paper-and-pencil "discretion scale" were being trusted with the results of their tests. Moreover, all secret Ss were required to sign the statement, "I hereby swear (affirm) that I will maintain in confidence, and will in no way disclose any scores or results of this research," and this statement was signed in witness by the E. This procedure combines

The reinforcing value of secret information¹

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Information was found to effectively reinforce an opinion response, and this result could be unambiguously attributed to reinforcement rather than to some other facilitating effect of information. Secret information and freely communicable information did not differ in their reinforcing effectiveness (N = 90).

A variety of studies indicate that information may be used as a reinforcer of instrumental responses. Such studies show that response strength depends upon

informational reinforcement in human instrumental conditioning (Jones, 1966), verbal discrimination learning (Spence, 1964), conditioning of attitudes (Weiss, 1968), perceptual-motor performance (Brown, 1949), and even in the secondary reinforcement of white rats (Egger & Miller, 1962) or fixed-ratio performance of pigeons (Hendry, 1969).

Brock's (1968) commodity theory of the transmission and value of information proposes that recipients of information value secret information more highly than they do information that is freely communicable. Brock's research on the value of information and the research on informational reinforcement may be combined to yield the prediction that