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ABSTRACT

Eighty undergraduate students participated in an investigation of the effects on acquisition of immediate versus 30-second delay of reinforcement under either known or unknown response contingency conditions. The students in the four experimental conditions were required to depress three buttons in proper senquence. Following a correct response, the proper sequence systematically changed. The task was to discover the rule which determined how the sequence changed. Criterion was three consecutive correct responses. A two-way analysis of variance demonstrated significant main effects for both the temporal reinforcement delay and response contingency condition, and for the interaction effect. Immediate reinforcement facilitated acquisition better than reinforcement that was delayed 30-seconds. Acquisition was also better facilitated when the subject had knowledge of the response contingency. The interaction effect demonstrated that the difference between acquisition rates for immediate and delayed reinforcement increased when the subject was unaware of the response contingency. The results affirmed the findings of research supporting the use of immediate and contingent reinforcement for acquisition. (Author/GK)

Delay of Reinforcement and Knowledge of Response Contingencies in Human Learning

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Running Head: Delayed Reinforcement

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The consistent demonstration in research using non-humans that a learning decrement results as a function of increasing the reinforcement delay interval is much less stable in investigations using students (Renner, 1964). While Sassenrath, Yonge, and Shrable (1968) found that immediate feedback facilitated learning better than delayed feedback, in the same year two of the same investigators (Sassenrath & Yonge, 1968) reported delay groups learned better than immediate feedback groups. The effect of delaying reinforcement in classroom-related learning has varied as a function of the nature of the task (Bourne, 1957: Sax, 1960; Wittrock, 1964; Kulhavy, 1971) and task meaningfulness and difficulty (Angell, 1949; Hockman and Lipsitt, 1960). Differing results have also emerged by varying the length of the intertrial interval (Markowitz & Renner, 1966; Frayer, 1971; Piper, 1971; & Sturges, 1972).

The intertrial interval, or temporal span from the termination of one response to the initiation of the next response, is apparently the critical parameter in delay or reinforcement studies. The period of time following a correct response but prior to the reinforcement is the pre-reinforcement interval. The period of time following the reinforcement but prior to the next response is the post-reinforcement interval. Boersma (1966) contended that extending the pre or post-reinforcement interval is not sufficient to inhibit learning, but that interpolated, competing responses are. Brackbill, Bravos, and Starr (1962) have suggested a person maintains a memory trace of a correct response and that competing responses during the pre-reinforcement interval interfere. Markowitz and Renner (1966) have dissagreed, contending that a person does not mediate until realizing a correct response was made; i.e., during the post-reinforcement interval. Interpolated responses during the pre-reinforcement interval would, therefore, not be competing.

Markowitz and Renner (1966) pointed out that many studies (e.g., Brackbill and Kappy, 1962) included knowledge of results at the end of the intertrial interval, re-establishing the lost memory trace resulting from the initial delay. They contended that a reinforcement delay would decrease learning if the later knowledge of results were omitted.

The present investigation was designed to determine the effects of delayed reinforcement with and without re-establishing the response contingency through post-reinforcement knowledge of results. It was hypothesized that 1.) with post-reinforcement knowledge of results the inhibiting effect from delayed reinforcement would diminish because the subject would not need to mediate during the delay interval, 2.) without post-reinforcement knowledge of results mediation would be necessary because the interpolated responses would have competing properties causing the reinforcement delay to inhibit learning, and 3.) delayed reinforcement and the exclusion of post-reinforcement knowledge of results would produce inhibitory effects which were additive. Thus, there were four conditions. Reinforcement was either immediate (I) or delayed (D) for 30-sec and the response contingency was either known (K) by giving post-reinforcement knowledge of results or unknown (U) by withholding post-reinforcement knowledge of results.

Method

Subjects

Subjects were 80 undergraduate student volunteers enrolled at Kansas State University. The students were randomly assigned to four groups. There were 37 males and 43 females.

Apparatus

The control panels for the first author and the student were 6.4 mm by 23.0 mm metal chassis mounted on a 30.5 mm by 52.0 mm wooden base. A 1.0 m by 1.5 m cardboard partition was placed upright between the control panels. These materials were painted flat black. The student's panel had three neon lights mounted 2.6 mm apart horizontally and 1.9 mm from the top of the panel. Red acetate was placed in front of each light. One normally-on push button was mounted directly under each light and 1.9 mm from the bottom of the panel. A neon light was centered vertically and mounted 1.3 mm from the left edge of the panel. A yellow plastic cap was placed over this light. The author's control panel was identical to the student's except there was no yellow light. Two mercury switches were secured to the base and to the right of the control panel to activate the timers. There were two Hunter automatic interval timers with silent relays to the left of the control panel. A cassette recorder with 15-min tape was placed beside the timers.

The cassette recorder and tape were used to produce an audible click each 15-sec to signal the start of each trial. Depression of the three push buttons by the student was monitored by the author with the three red panel lights. Each mercury switch controlled one of the timers. The timers were both set for either a 0-sec or 30-sec delay interval. The timers turned on the yellow reinforcement light on the student's panel. Turning the mercury switch off turned out the reinforcement light. The author's three push buttons, when sequentially depressed, turned on the student's three red lights in corresponding sequence. The second timer was necessary if the student emitted a second correct response during the existing 30-sec delay interval.

Procedure

When seated at the apparatus, the student was told that the task was to depress all three buttons in the proper sequence, depressing each button only once. The student was told that the yellow light would come on if the sequence was correct. Also, the student was informed that the correct sequence would change after each correct response, and that the ultimate task was to determine the rule which identified how the sequence changed. Students in the delayed reinforcement (D) groups were told that when the yellow light came on, it would not necessarily mean that the last response given was the correct one. In the contingency known (K) groups where post-reinforcement knowledge of results was given, students were told that after the yellow light came on, the three red lights would come on one at a time in the same sequence the student had used in correctly responding. Thus, all students were told the yellow light signified a correct response. Students in the D groups were told the correct trial may have been any one of the responses since the last reinforcement. Students in the K groups were aided by a visual display of the correct response sequence.

The 15-sec intertrial interval tape made an audible click to start each trial. On a correct trial the author threw the timer switch to activate the reinforcement process. If a second correct response followed in the next two trials, the second delay timer was activated. For the KI students the reinforcement light came on immediately. To identify the response contingency for the student, the author depressed his three buttons duplicating the student's correct response. This sequence appeared on the student's control panel. The author then turned off the timer switch, turning out the yellow reinforcement light. The cassette tape again clicked and a new trial began. After a reinforcement following a correct response, however, the sequence changed. The starting point moved back one button to the left. For example, if the first correct sequence was 2, 3, 1, the next correct sequence following a reinforced response became 3, 1, 2. This was followed by 1, 2, 3, etc. For the students in the KD group, the procedure was the same, except that the timer delayed the onset of the reinforcement light for 30-sec. After the light came on, the author again duplicated the student's correct response. The students in the UI and UD groups did not receive response confirmation from the red lights. Thus, they were not informed of the response contingency. To summarize, the reinforcement light was activated for all students under either I or D conditions, but only the students in the K conditions received knowledge of results via the three red lights. The criterion was three consecutive correct responses, or 60 trials. Maximum time for testing was 15-min. The data were analyzed by using a completely randomized two-way analysis of variance.

Results

One student in the UI condition and two students in the UD conditions did not complete the experiment. Their data were discarded and alternate students were selected.

The data analyzed were total number of trials to criterion. The means for the KI and UI conditions were 12.25 and 14.45, respectively. The means for the KD and UD conditions were 32.60 and 55.85, respectively. Standard deviations ranged from 5.99 to 9.19. Table 1 summarizes the two-way analysis of variance which resulted in significance for delay of reinforcement effects, $\underline{F}$ (1,76) = 134.94, $\underline{p} < .001$; response contingency effects, $\underline{F}$ (1,76), $\underline{p} < .001$; and their interaction $\underline{F}$ (1,76) = 15.68, $\underline{p} < .001$.

Insert Table 1 about here

The effects of temporal delay of reinforcement varied across levels of knowledge of the response contingency to produce the interaction shown in Figure 1.

Insert Figure 1 about here

Discussion

This investigation was supportive of the use of immediate and contingent reinforcement for a simple learning task. Delaying reinforcement clearly decreased learning. Removing post-reinforcement knowledge of results made interpolated responses during the delay interval competing, and further reduced learning as demonstrated by the interaction effect. Many researchers (Saltzman, Kanfer, and Greenspoon, 1955; Noble and Alcock, 1958; Brackbill and Kappy, 1962; Smith, 1963; Brackbill, Wagner, and Wilson, 1964; Sturges, 1970) have found non-significant results between immediate and delayed reinforcement. These studies, however, either excluded interpolated responses and/or included post-reinforcement knowledge of results. In the present investigation, the UD group did poorest. Because the response contingency was not identified via post-reinforcement knowledge of results, a valid delay interval was created. Necessary mediation during this delay was impeded due to competing responses.

Students in the KD group learned better than students in the UD group because mediation during the delay interval was not needed. The interaction showed the effects of reinforcement delay and an unknown response contingency to be additive. Because of the immediate temporal proximity of the correct response and reinforcement, students in the KI and UI groups learned best. Since students in both of these groups were instructed that reinforcement would immediately follow a correct response, identification of the response contingency should not have provided additional information.

Many studies have used meaningful verbal material rather than simple learning tasks, and have extended the delay interval to as much as 7-days (Bilodeau and Bilodeau, 1958). Future delay of reinforcement research which varied task difficulty under conditions of known and unknown response contingencies would seem worthwhile. Optimum delay intervals should vary as a function of the nature of the learning task involved.

Sturges (1972) found that with equivalent pre-reinforcement intervals, persons learned less the longer the post-reinforcement interval became. A person would not necessarily be expected to repeat a given behavior immediately after it was reinforced; i.e., a post-reinforcement interval of time would elapse. A study of the effects of increasing the post-reinforcement interval with and without post-reinforcement knowledge of results could provide additional, qualifying data.

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Table 1

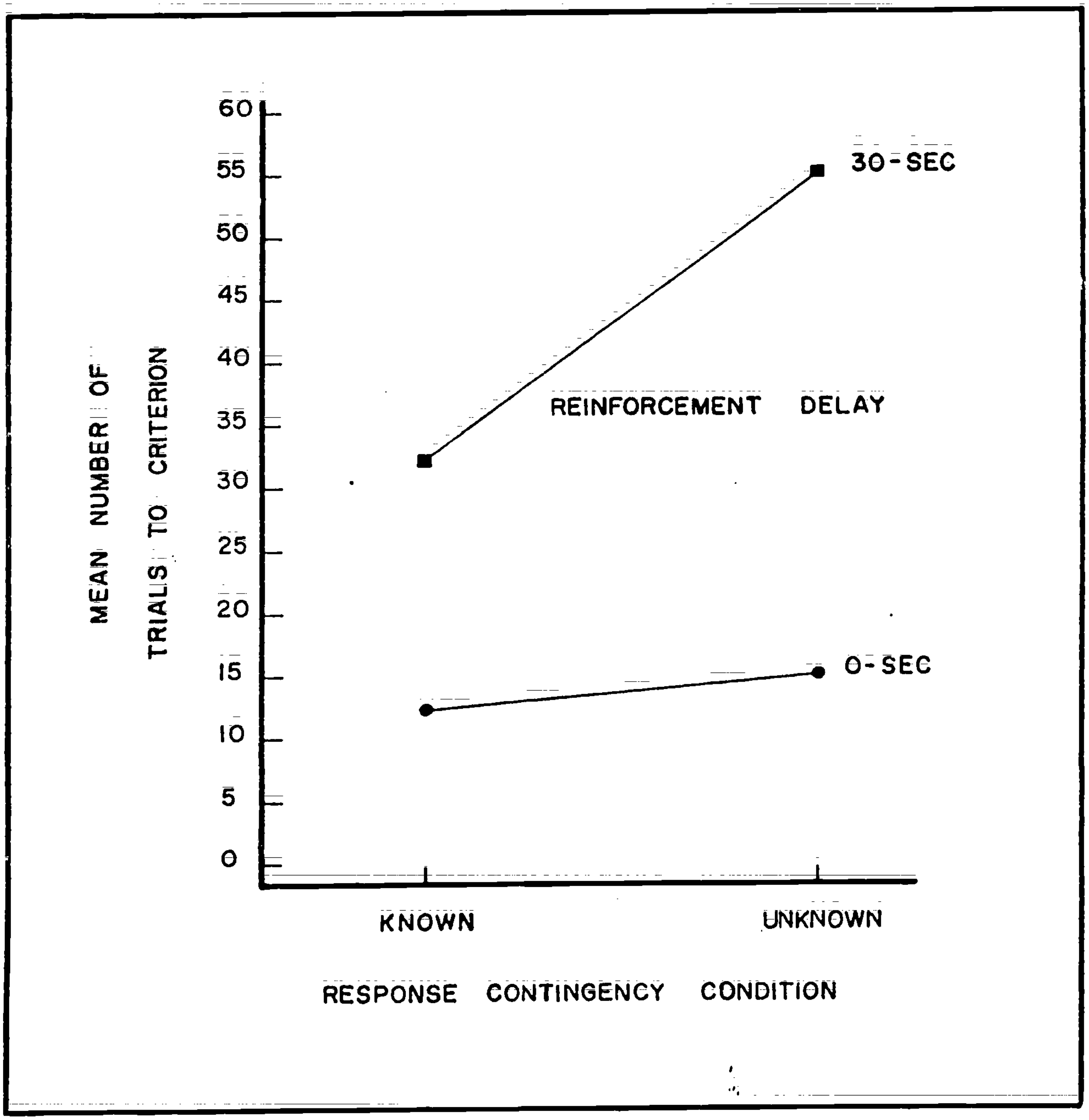
Two-way Analysis of Variance
Summary Table

Source of variation	*df*	*SS*	*MS*	*F*
Total	79	34,257.40	446.29	
Reinforcement (I-D)	1	19,065.33	19,065.33	134.94*
Contingency (K-U)	1	3,238.53	3,238.53	22.92*
I-D X K-U	1	2,215.49	2,215.49	15.68*
Error	76	10,738.05	141.29	

* $p < .001$.

Figure Caption

Figure 1. Interaction effect between reinforcement delay interval and response contingency condition.


MEAN NUMBER OF
TRIALS TO CRITERION
60
55
50
45
40
35
30
25
20
15
10
5
0
30-SEC
REINFORCEMENT DELAY
0-SEC
KNOWN
UNKNOWN
RESPONSE CONTINGENCY CONDITION