EFFECTS OF DELAY OF INFORMATION FEEDBACK AND LENGTH OF POSTFEEDBACK INTERVAL ON LINEAR PROGRAMED LEARNING

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

Frederick J. Boersma

1965

This is to certify that the

thesis entitled

EFFECTS OF DELAY OF INFORMATION FEEDBACK AND LENGTH OF POSTFEEDBACK INTERVAL ON LINEAR PROGRAMMED LEARNING

presented by

Frederick J. Boersma

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Education

Bernard R. Corman
Major professor

Date December 14, 1964

O-169

ABSTRACT

EFFECTS OF DELAY OF INFORMATION FEEDBACK
AND LENGTH OF POSTFEEDBACK INTERVAL
ON LINEAR PROGRAMED LEARNING

by Frederick J. Boersma

The controversial findings on delay learning were attributed to the failure of experimenters to control for the confounding effects of the intertrial interval with delay of information feedback (DIF), and post-information feedback delay (PIF). The study attempted to determine the independent effects of these delay variables in a complex learning task in which subjects (Ss) learned a series of symbolic logic rules by programed instruction. Fifty-six Ss served individually in a factorial design which combined two delays of IF (0 and 8 sec.), two post-IF intervals (0 and 8 sec.) and a sex factor.

The data did not support the prediction that human learning would be facilitated by increasing the post-IF interval, nor did it yield a significant delay or IF effect. But, it did show that a simple explanation in terms of the independent effects of delay of IF or post-IF is inadequate. In addition, the analyses of answer latencies revealed that Ss spent more time examining correct answers when treatments were associated with delayed rather than immediate-IF. As

predicted, all delay effects for response latencies were insignificant. A competing response interpretation of delay, similar to that developed by Spence and Denny, was formulated with respect to error scores, answer latencies and the delay variables.

EFFECTS OF DELAY OF INFORMATION FEEDBACK AND LENGTH OF POSTFEEDBACK INTERVAL ON LINEAR PROGRAMED LEARNING

By

Frederick J. Boersma

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

College of Education

1965

ACKNOWLEDGEMENTS

To the members of my Doctoral committee, I owe a special word of thanks. To Professor Bernard R. Corman, for his valuable guidance in the development of my Doctoral program, and assistance in the direction of this dissertation, I am especially indebted. I also wish to express my appreciation to Dr. Walter R. Stellwagen for his assistance in the complexities of the experimental design. A further word of thanks is due to Dr. M.R. Denny and Dr. Jean LePere for their constructive criticisms of this study, and to Cornelius VanderVeen for his aid in experimentation.

Finally, to my wife, Linda, for her consistant support throughout my Doctoral program, I am grateful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

THEORETICAL ORIENTATION AND REVIEW OF LITERATURE

Delay of reinforcement as an independent variable in the experimental study of learning dates at least to Watson's 1917 experiment on delay of reward in a digging response (Renner, 1964). Watson found that a 30 second delay had no effect on acquisition and questioned the then widely held supposition that receiving a reward "stamped in" the most recent of a learner's responses. Watson's experiment marked the beginning of a continuing controversy about how empirically established relationships between the immediacy of reinforcement and acquisition are to be interpreted.

Contemporary theorists have mainly favored and extended either Hull's (1943) "law of effect" interpretation or Guthrie's (1952) "contiguity" explanation, although a few theorists have advocated two-factor theories in an attempt to bridge the gap between these conflicting positions (Skinner, 1938; Mowrer, 1960; Spence 1956, 1960). In part, theoretical distinctions between "contiguity" and "effect" interpretations of reward have been narrowed by the realization that differences often represent linguistic preference. For instance, even though Hull spoke of "drive-reduction" and Guthrie, "stimulus change" their respective students (e.g., Spence, 1956; and Sheffield, 1954) arrived at strikingly

similar interpretations of the role of reinforcement. Both Spence and Sheffield considered acquisition to be the result of the contiguous occurence of stimulus and response and held to Tolman's (1955) distinction between learning and performance.

In any case, the experimental evidence has not convincingly established the supremacy of any one monistic or two-factor theory, though there is little doubt that reinforcement does play an important role in controlling both animal and human performance. Research with animals has established that delay of reinforcement retards acquisition, that delay combines cumulatively with other variables within the immediate situation, and that delay leads to an increase in resistance to extinction when Ss can mediate the delay interval.

The explanation of these established relationships is in dispute. Spence (1956), argued that the constant delay of reinforcement situation, in which Ss remain without any necessity or opportunity for making the response to be learned, is a much more complex phenomenon than previously realized. A theoretical examination of classical and instrumental conditioning with respect to such delay gives considerable support to his position.

In classical and instrumental conditioning, for both animal and human Ss, delay of reinforcement appears to be either a form of partial reinforcement in which the proportion

of reinforcements is inversely related to length of the delay interval, or a form of experimental extinction in which the immediate situation remains unchanged and reinforcement fails to occur. This hypothetical interpretation of delay implies that the same frustration-aroused competing response tendencies which occur during extinction and lead to a decrement in conditioned response strength, will also occur during delay of reinforcement.

Spence (1956, p. 154) stated that "occuring as these responses do to essentially the same components as does the to be learned instrumental response they likewise become conditioned to them," and that once such competing responses are established, that they "will have the effect of increasing the time it will take the appropriate response (to occur)."

Rieber (1961), and a series of studies reported by Spence (1956), provided support for the supposition that maximum performance is dependent upon minimizing competing behavior (Carlton, 1954; Harker, 1950; and Shilling, 1951). Ramond's 1954 study, also reported by Spence (1956), hypothesized that competing behavior accumulates when Ss are not able to minimize conflicting behavior. A similar hypothesis has recently been proposed by Renner (1963).

Spence (1960), surmised, contrary to Hull's work-fatigue concept of inhibition, that failure of occurrence of a reinforcer following a response results in a type of

frustration inhibition. He stated that the strength of this frustration varies directly with the strength of the non-reinforced response tendency, and that this effect occurs since Ss have learned to expect or anticipate reward which no longer occurs. This explanation led Spence to refer to his theory as a type of S-R expentancy theory.

Spence's interference-frustration notions of inhibition are similar to those proposed by Denny and Adelman (1955). Denny and Adelman hypothesized that frustration (non-reward) constitutes an eliciting state of affairs where cues associated with non-reward acquire the property to elicit avoidance responses, and that these avoidance responses compete with the to-be-learned responses. Similarly, Amsel (1958) stated that introduction of delay into a previously reinforced situation results in an emotional response of frustration which promotes conditioned avoidances and a decrement in performance. Additional support for this frustration hypothesis has been reported by Adelman and Maatsch (1955). These Es found that rats allowed to escape from an empty goal box during extinction showed less loss of original habit strength than did those who were retained in the box. Adelman and Maatsch's data indicated that escape from frustrating conditions of extinction is conducive to the elicitation of fewer competing responses, and consequently, greater resistance to extinction.

A somewhat more detailed analysis of the processes of acquisition and extinction in terms of competing responses has been published by Pubols (1958). Pubols hypothesized that resistance to extinction varies inversely with number of competing responses which have been extinguished during acquisition, and that readaptation to the original situation is a necessary condition for extinction. His position suggested that the greater the opportunity for competing responses to occur, the slower the rate of acquisition and the greater the resistance to extinction.

Although there are many theoretical interpretations of why constant delay appears to operate similarly to partial reinforcement during extinction, in experiments with animals this effect is probably best attributed to the acquisition of situational and/or response produced cues formed in original learning which become reactivated during extinction and make it difficult for Ss to discriminate between conditions of acquisition and extinction.

Researcher's have found it necessary to introduce additional variables and/or constructs to explain the effects of delay of reinforcement in human, as distinct from animal learning. Much of the research in human learning has dealt with the influence of delay of knowledge of results (KR) in simple psychomotor tasks. Greenspoon and Foreman (1956) found that increasing length of delay interval before informing Ss about their performance reduced rate of acquisition

in learning to draw a three inch line. A replication of the Greenspoon and Foreman study, using tighter controls, by Bilodeau and Ryan (1960), reported that delay of KR does not retard psychomotor performance, but a similar study by Ryan and Bilodeau (1962) proved inconclusive. The majority of reports, however, have indicated that delay does not retard attainment of a performance standard (Bilodeau and Bilodeau, 1958; Denny et al., 1960; McGuigan, 1959; Noble and Alcock, 1958; and Saltzman, Kanfer and Greenspoon, 1955). The delay of KR in these studies typically has been up to 30 seconds, although Bilodeau and Bilodeau (1958) used a seven day delay interval.

Even more controversial findings have been reported when concept formation and verbal learning tasks were emphasized. For example, though Bourne (1957) did find that delay of information feedback (IF) retarded concept attainment in his 1957 study, his replication using tighter controls, failed to produce a similar effect (Bourne and Bunderson, 1963). In verbal learning, Saltzman (1951) found that delay inhibited acquisition, whereas Brackbill and Kappy (1962) found that it had no effect on learning. Generally speaking, reviews of the literature on delay in more complex forms of human learning have reported that performance decreases as delay increases (Ammons, 1956; Renner, 1964; and Wolfe, 1951).

More consistent relationships have been reported in the programed learning literature where the majority of the studies support Skinner's (1954) supposition that immediate reinforcement is a necessary condition for effective learning.

For example, Angell (1949) using a Pressey-type punchboard, and Meyer (1960) using a linear program, found that students receiving immediate KR had significantly higher final examination scores than did those who were given results at the next class meeting. Coulson and Silberman (1960), and Lumsdaine (1960) have also attributed the effectiveness of autoinstructional material to the immediacy of KR as a reinforcer. But, other studies have reported that delay of KR has no effect on learning (Evans, 1960; Feldhusen, Ramharter and Birt, 1962; Hough and Revsin, 1963; McDonald and Allen, 1962; and Moore and Smith, 1961). And while a number of other researchers have reported significant differences in favor of immediate KR, they were mainly concerned with testing different methods of providing feedback (e.g., Krumboltz and Bonawitz, 1962; and Kanner and Sulzer, 1961).

Thus, though the study of experimental delay goes back nearly 50 years, and though this research has demonstrated the retardation effects of delay in lower organisms, it has failed to generate such consistent findings with humans.

In an attempt to resolve some of these contradictions, Bilodeau and Bilodeau (1958) ran a series of five psychomotor experiments to see what effect, if any, the intertrial interval (ITI) had on performance. Their rationale was that Es had failed to consider the confounding effects of ITI with delay or KR in the majority of the psychomotor studies. Four

of these experiments indicated that the ITI was a critical variable in this type of learning task, while the fifth experiment suggested that post-KR delay may facilitate performance. These studies showed that delay of KR, up to a week did not effect performance in drawing a three inch line, but that performance varied inversely with length of the ITI. Denny, et al. (1960) attempted to control for possible carry-over effects associated with the familiar three inch line used by Bilodeau and Bilodeau by having Ss draw 60 "glubs" (also a three inch line). They found, as did Bilodeau and Bilodeau, that the period of time between responses was the crucial variable, i.e., the ITI (better learning with shorter intervals), and that delay of KR did not effect performance. Moreover, they surmised that "...previous experience in conjunction with knowledge of the response to be learned will diminish the importance of the intertrial interval as a variable" for very simple motor tasks (Denny, et al., 1960, p. 327). Data reported by Becker, Mussina and Persons (1963) support this hypothesis in that they found the only significant variable operating in the drawing of a familiar three inch line was that of KR itself. Although their findings supported Bilodeau and Bilodeau's (1958) position that delay of KR is not crucial in simple psychomotor tasks, their data did not yield a similar ITI effect.

Another recent attempt to explain the differential effects of IF and ITI was made by Bourne and Bunderson (1963).

To control for possible confounding effects of the ITI with delay of IF and post-IF delay, they developed an experimental design which permitted them to vary these variables orthogonally, but maintain an average ITI between treatments. Bourne and Bunderson used this design to replicate Bourne's 1957 concept formation experiment. In this replication they found that delay of IF did not retard concept attainment, that increases in the post-IF interval lead to significant decreases in error scores, and that the post-IF effect became more prevelant as concept complexity increased.

Bourne and Bunderson (1963) surmised that the discrepancy between Bourne's 1957 and their 1963 study, and the majority of the research reported on human delay learning, is due to the fact that Es have failed to control for possible confounding effects of ITI with the post-feedback interval, and to consider such methodological factors as task complexity.

Thus, it appears that the ITI ceases to function as a crucial variable for very simple tasks when Ss have had previous experience with these tasks (Becker, Mussina and Persons, 1963), and for complex tasks (five dimension concepts) when Ss have not had previous experience with such tasks (Bourne and Bunderson, 1963). Results from studies employing wide ranges of task complexity which build in experience, as in programed instruction, are needed in order

to determine optimal acquisition intervals for such tasks, and to demonstrate the effects of complexity on performance.

Brackbill and Kappy (1962) hypothesized that Ss used mediational cues acquired during acquisition to bridge the time gap between response and KR in their serial learning experiment. They suggested that the differential delay effects reported in human learning literature may be due to the fact that experimental tasks were such that Ss could mediate during the delay interval in some cases, but not in others. In an attempt to provide support for this mediational hypothesis, Brackbill (1964) replicated the 1962 study by initiating an interpolated task during the delay interval. She found that in this instance delay retarded performance and concluded that Ss were unable to mediate the delay due to interfering (competing) behavior elicited by the interpolated task. It should be noted, however, that even though Brackbill and Kappy (1962), and Brackbill (1964), did control for the ITI, they did not consider the effects of the post-delay on performance, as did Bourne and Bunderson (1963), and that consequently, their data is confounded and misleading.

But, Brackbill and Kappy's mediation hypothesis is in agreement with Lorge and Thorndike's (1935) earlier questioning of the premise that delay of IF or KR retards all forms of performance. Lorge and Thorndike suggested that there are delay situations (unfilled) in which Ss can

reinstate (symbolically) some form of response after-effect, and reach criterion just as quickly as if they had received immediate reinforcement. Similar mediational and/or response produced delay interpretations have been developed by other psychologists (e.g., Bilodeau and Bilodeau, 1958; Brown, 1949; and Erickson and Lipsett, 1960).

These contradictory findings within the delayed learning literature might also be attributed to innate differences between animal and human learning with respect to the reinforcement variable. Such a differential explanation of reinforcement would hold that it is appropriate to speak of "reward" in animal learning, but that the constructs of "knowledge of results" and "information feedback" are more exact in human learning. This distinction, however, appears to be hypothetical rather than demonstrable, since the motivational characteristics of the Ss used in the experiment usually determine whether or not reward (incentive) is provided, and not differences in the reinforcement variable per se. For example, if intrinsic motivation is insufficient, as with animals and very young children, reward is usually provided; whereas, if it is adequate, as with normal adults and older children, only knowledge of results (KR) or information feedback (IF) is given. Thus, it appears that reinforcement, KR and IF are operating similarly in both animal and human learning. Furthermore, these terms have been used interchangeably by a number of prominent

psychologists (e.g., Bourne and Bunderson, 1963; Brackbill and Kappy, 1962; and Skinner, 1954).

Certainly unwarranted in human learning is the complete acceptance, without qualification, of delay of reinforcement generalizations which state that a few seconds delay between response and reinforcement may mean the difference between maximal learning and no learning whatever. There are, as we have shown, situations in which Ss appear to mediate the delay interval and minimize its decremental effect. The frequent conflicting findings reported for the effects of delay in human learning may be due to the fact that Es have generally failed to control for confounding effects of ITI with delay of IF and post-IF. Even in the Bourne and Bunderson (1963) study on concept formation, which did control for confounding effects of delay with ITI, the data were not representative of the more complex forms of school learning.

The experiment to be reported in this paper has attempted to extend existing knowledge on human delay learning by examining the independent effects of delay of IF, and post-IF delay, on performance of a programed learning task in symbolic logic. This study differed from the previously reported learning research on delay, in that the differential complexity of material within the program necessitated the use of S, rather than the E controlled, feedback intervals. This initiated a new variable into Bourne and

Bunderson's (1963) design on which the present study was based. But, this change in experimental procedure was imperative if Ss were to receive adequate IF. The significance of this study lies in its close resemblance to actual school learning, and in its use of a variable, not previously examined as a function of delay, i.e., the S controlled feedback interval.

It was predicted that the post-IF interval would be the crucial variable in this complex learning task, and that the effect of delayed IF would be negligible. It was further surmised that the S controlled feedback interval would not correlate with error scores, and that the data would resemble that obtained by Bourne and Bunderson (1963), since for all practical purposes, the E had controlled for confounding effects of ITI with the delay variables.

METHODOLOGICAL CONSIDERATIONS

Subjects

Fifty-six volunteer students, 28 men and 28 women, enrolled in the College of Education at Michigan State University were used as Ss in this experiment. Their median age was 20 years and their cumulative mean grade point average was 2.66. These Ss were randomly assigned to the four experimental conditions (14 per experimental treatment) to be described below, with sexes equally represented in each treatment.

Procedure and Apparatus

The Linear program in symbolic logic developed by Evans, Glaser and Homme (1962) was modified for use in this experiment. The final form of the modified program consisted of seven rules to be learned in 78 frames (See Appendix A). Items within the program progressed from simple to complex. Each frame was programed according to the Ruleg System developed by Evans, Homme and Glaser (1962). Composed responses were used in order to avoid cues associated with constructed responses. The symbolic logic material was chosen since it permitted the E to control for previous experience, was fairly complex and yet held Ss' interest.

The apparatus consisted of a MTA Scholar teaching machine, a Hunter timer and an Esterline-Angus recorder. The teaching machine and timer were wired so that the E could control the delay intervals. The Esterline-Angus recorded latency to response and amount of time the S spent examining the correct answer. The program was advanced by the internal mechanism of the apparatus when Ss pressed a button.

Subjects were allowed to control the amount of time they spent on each frame. The Ss constructed a response following which either immediately or after an eight second delay they were informed of the correct answer. The amount of time spent examining the correct answer was also controlled by Ss. After this second self-determined interval they were exposed again, either immediately or after an eight second delay, to the next frame. In all treatments, the stimulus material and the S's constructed response were withdrawn from view during the delay intervals. The lengths of the respective delays, i.e., the delays of IF and post-IF, were predetermined as a function of the treatment specifications. Detailed initial oral instructions were given before exposure to any of the programed materials to each S regarding the experimental procedure (See Appendix B). No further instructions were given to the Ss during the period of experimentation.

Each S received a five minute break midway through the program and before administration of a criterion test after completion of the program. This test consisted of 10 true-false questions, 10 recall questions and 8 deductive-proof questions (See Appendix C); an open-ended general information questionnaire was also included in the test battery (See Appendix D). Average total program running time per S was approximately two hours, and varied from one hour and twenty-five minutes to two hours and thirty-five minutes.

Design

A 2 X 2 X 2 factorial design was used with two delays of IF (0 and 8 sec.), two lengths of post-IF interval (0 and 8 sec.) and a sex factor. This experimental design permitted the E to vary the effects of delay of IF (DIF) and post-IF (PIF) orthogonally, to maintain an average inter-trial interval of 8 seconds between these two factors, and to control for possible massing effects between the various treatment conditions.

Design Note

Due to the differential complexity of material within the symbolic logic program, it was necessary to allow Ss to control exposure time to the correct answer, i.e., the length of the IF interval. This initiated a new variable into Bourne and Bunderson's experimental design on which the present study was based. However, this change was imperative

if the Ss were to receive adequate information feedback. It was assumed that this change would not alter the relationship between length of IF intervals and number of errors associated with the respective treatment conditions. All zero order correlations indicated that longer feedback intervals were not accompanied by lower error scores.

Treatments

The four treatment conditions were identified as follows: 0-0 indicated complete self-pacing by Ss, i.e., no delay of IF or post-IF delay; 0-8 indicated no delay of IF but an eight second post-IF interval; 8-0 indicated an eight second delay of IF but no post-IF delay; and, 8-8 signified an eight second delay interval before and after exposure to correct answer, i.e., before and after IF.

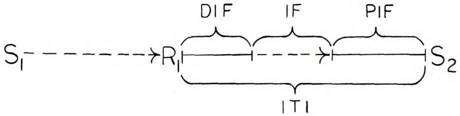
Dependent Variables

The dependent variables used in this study were two error scores, a response latency score and an answer latency score. Number of errors indicated to what degree Ss responded correctly to program and criterion test items, and to the eleven deductive-proof and easiest items within the program. The correlation between program and criterion error scores was .875. Response latency referred to the average amount of time spent by Ss responding to programed items, and answer latency to the average amount of time spent by Ss examining the correct answers to these items.

Figure 1 represents the temporal intervals. The intertrial interval was defined as that period of time between response and the presentation of the next stimulus. The delay of IF interval (DIF) referred to the amount of time Ss waited after responding before receiving IF, while the post-IF interval (PIF) referred to the amount of time Ss waited after receiving IF before being exposed to the next frame. The IF interval was synonomous with the answer latency variable.

FIGURE 1

Temporal Intervals Common to the Present Study



Reliability

Scorer reliability (test-retest) over a seven day period was .963 for program errors and .981 for criterion test error scores. Recorder (interjudge) reliability was .994 for response latencies and .999 for answer latencies. The reliability of the criterion test was .843 (KR 21).

Hypotheses

General Hypothesis:

Recent research in the area of human learning suggests that the post-IF interval may be a critical

variable in mediated tasks and that delay of IF may not. The data indicate that human learning may be facilitated by increasing the post-IF interval and that the temporal relationship between delay variables is negligible. This study will attempt to replicate these variables in a complex learning task.

Statistical Hypotheses:

A. Analysis of summated error scores on program and criterion test

1. The delay of IF interval will not contribute a significant source of variance to the analysis, i.e., an increase in the delay of IF interval will not be accompanied by an increase in mean number of errors. Rejection of this hypothesis will give support to the traditional interpretation that delay retards acquisition.

2. The post-IF interval will yield a significant source of variance such that an increase in the post-IF interval will be accompanied by a decrease in mean number of errors.

3. The sex factor will not contribute a significant source of variance to the analysis, i.e., it is hypothesized that females will perform as well as males on this task.
4. The DIF and PIF interaction will be insignificant. Rejection of this hypothesis will indicate that delay of IF does affect post-IF delay, and that this effect is not constant over all levels of delay of IF in this form of learning.
5. The DIF by sex, and the PIF by sex interactions will not yield a significant source of variance to the analysis. Rejection of these hypotheses will indicate that the delay intervals have differential effects on sex.
6. The three-way interaction between DIF, PIF and sex will be insignificant indicating that these variables are independent.

B. Analysis of mean response latency scores

There will be no significant statistical findings associated with any of the main or interaction effects for the analysis

of response latency scores. This will indicate that amount of time spent to solution will not differ (correlate) with the various treatment conditions or sex.

C. Analysis of mean answer latency scores

1. The delay of IF interval will not contribute a significant source of variance to the analysis, i.e., an increase in the delay of IF interval will not be accompanied by an increase in answer latency scores. If this hypothesis is rejected, it will indicate the <u>S</u>s spent a significantly greater amount of time examining a correct answer when IF is delayed than when it occurs immediately.

2. It is hypothesized that all other main effects and interactions will be insignificant. If this supposition is supported, it will indicate that PIF and sex do not affect answer latency scores, and that DIF, PIF and sex do not correlate with each other.

RESULTS

Analyses of Error Scores

The analysis of variance summarized in Table 1 was performed on total program error scores. All main and interaction effects were insignificant except the delay of IF by post-IF interaction ($p < .05$). A similar analysis, summarized in Table 2, was performed on criterion error scores. In this analysis, the delay of IF by post-IF interaction failed to reach the .05 level of significance; however, it did exceed the .10 tabled value of the F distribution. Figure 2 represents geometrically the delay of IF by post-IF interactions for total program and criterion error scores.

Summarized mean and variance data for total program error scores is presented in Table 3. Individual tests between treatment variances revealed at the .01 level that treatment 8-0 was significantly more variable than treatments 0-0 and 8-8. All other tests between program error variances were negligible. Table 4 denotes mean and variance data for criterion error scores. All individual tests between program error variances were insignificant.

The analysis of variance for error scores on the eleven deductive-proof items within the program is presented in Appendix F. Here again, as in Table 1, only the delay of

TABLE 1

Analysis of Variance on Program Errors

Source	DF	F
Sex	1	.603
Delay of IF (DIF)	1	1.212
Postfeedback interval (PIF)	1	.004
Sex X DIF	1	.691
Sex X PIF	1	.041
DIF X PIF	1	5.640*
Sex X DIF X PIF	1	1.301
Residual MS	48	(37.50)

*$p < .05$

TABLE 2

Analysis of Variance on Criterion Test Errors

Source	DF	F
Sex	1	.002
Delay of IF (DIF)	1	2.161
Postfeedback interval (PIF)	1	.018
Sex X DIF	1	.001
Sex X PIF	1	.000
DIF X PIF	1	2.821
Sex X DIF X PIF	1	2.922
Residual MS	48	(22.59)

FIGURE 2

A Geometric Interpretation of The Delay
Of IF by Post-IF Interaction For
Program and Criterion Test Error Scores

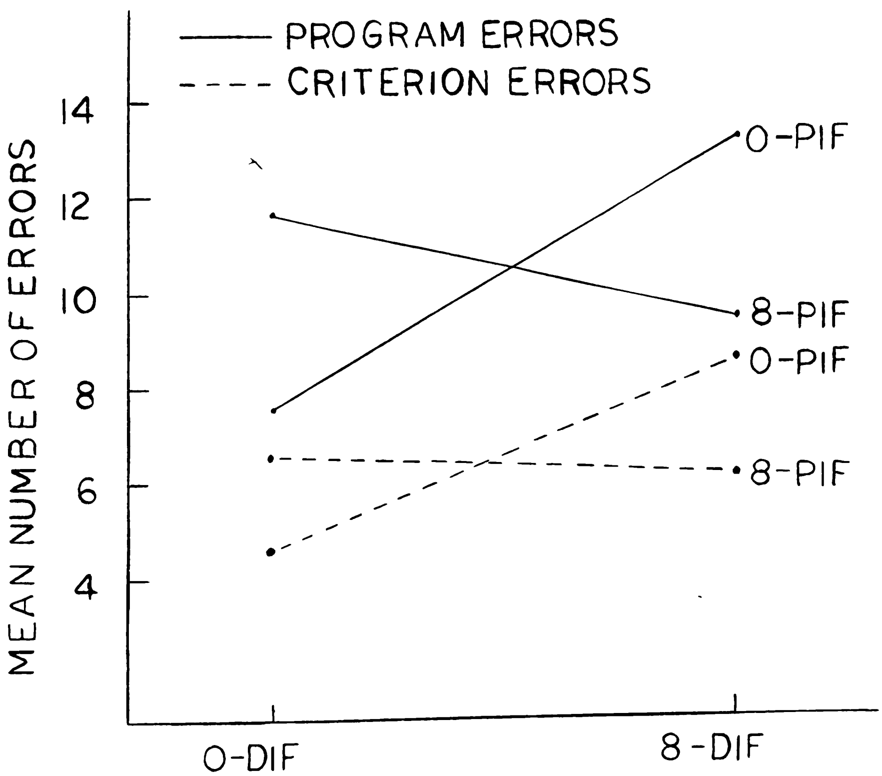


TABLE 3

Summarized Mean and Variance Data
For Program Error Scores

Source	N	Mean	Variance
Male	28	11.15	42.78
Female	28	9.87	32.23
0-0	14	7.62	23.74
0-8	14	11.62	35.82
8-0	14	13.30	67.51
8-8	14	9.52	22.96
DIF-0	28	9.62	29.78
DIF-8	28	11.41	45.24
PIF-0	28	10.46	45.63
PIF-8	28	10.57	29.39

TABLE 4

Summarized Mean and Variance Data
For Criterion Test Error Scores

Source	N	Mean	Variance
Male	28	6.52	21.70
Female	28	6.47	23.49
0-0	14	4.59	26.29
0-8	14	6.55	28.55
8-0	14	8.58	19.19
8-8	14	6.27	16.35
DIF-0	28	5.57	27.42
DIF-8	28	7.43	17.77
PIF-0	28	6.59	22.74
PIF-8	28	6.41	22.45

IF by post-IF interaction was significant ($p < .05$).

The analysis of variance, summarized in Appendix G, was performed on error scores for the eleven easiest program items. These items were operationally defined as those items on which average response latencies were equal to or less than 15 seconds. All main and interaction effects were insignificant for this analysis. These data indicate that the delay of IF by post-IF interaction is not present for program errors when length of program and/or difficulty is removed from the analysis.

Appendices H and I summarize respectively mean and variance data for the eleven deductive-proof and easy items. The largest error scores in both of these appendices, as in the analysis of program and criterion test material, were associated with treatment 8-0. A rank order between treatments similar to that observed in the analysis of program and criterion error scores was obtained for deductive-proof, but not for easy items.

Analyses of Latency Scores

The analysis of variance, summarized in Table 5, was performed on average total program response latency scores. A significant sex effect was found at the .05 level indicating that females spent less time responding to each frame on the average than did males. All other main and interaction effects were insignificant.

A similar analysis on average total program answer latency scores is presented in Table 6. This breakdown showed that female answer latency scores were on the average shorter than those of males ($p < .05$). And, that Ss spent a significantly greater amount of time examining correct answers when their treatments were associated with delayed feedback conditions ($p < .01$).

Tables 7 and 8 summarize respectively mean and variance data for average program response and answer latency scores. No significant variance differences were found for response latencies. But, the breakdown of answer latencies revealed that treatments associated with delayed IF were significantly more variable than those associated with immediate IF ($p < .05$).

Appendices J and K represent respectively the analyses of variance performed on average response and answer latency scores for the eleven deductive-proof items. As in the analysis of program response latencies, females were found to have significantly shorter response latency scores than males. However, the analysis of deductive-proof answer latencies failed to reveal, as did the analysis of program answer latencies, significant sex and delay of IF effects.

Appendix L gives mean and variance data for average deductive-proof response latency scores. Male response

TABLE 5

Analysis of Variance on Average Response Latency Scores

Source	DF	F
Sex	1	4.085*
Delay of IF (DIF)	1	.398
Postfeedback Interval (PIF)	1	.255
Sex X DIF	1	.105
Sex X PIF	1	.413
DIF X PIF	1	.543
Sex X DIF X PIF	1	.263
Residual MS	48	(134.67)

*$p < .05$

TABLE 6

Analysis of Variance on Average Answer Latency Scores

Source	DF	F
Sex	1	4.908*
Delay of IF (DIF)	1	12.676**
Postfeedback Interval (PIF)	1	.007
Sex X DIF	1	.268
Sex X PIF	1	1.266
DIF X PIF	1	1.911
Sex X DIF X PIF	1	.701
Residual MS	48	(2.80)

*$p < .05$

**$p < .01$

TABLE 7

Summarized Mean and Variance Data for
Average Response Latency Scores

Source	N	Mean	Variance
Male	28	48.83	185.19
Female	28	42.56	99.55
0-0	14	46.64	73.16
0-8	14	42.79	198.28
8-0	14	46.37	111.19
8-8	14	47.03	86.91
DIF-0	28	44.77	165.72
DIF-8	28	46.70	99.05
PIF-0	28	46.51	92.18
PIF-8	28	44.91	142.60

TABLE 8

Summarized Mean and Variance Data for
Average Answer Latency Scores

Source	N	Mean	Variance
Male	28	4.73	3.62
Female	28	3.74	1.97
0-0	14	3.11	2.18
0-8	14	3.77	.98
8-0	14	5.32	4.51
8-8	14	4.74	3.52
DIF-0	28	3.44	1.58
DIF-8	28	5.03	4.02
PIF-0	28	4.22	3.55
PIF-8	28	4.26	2.25

latencies, although failing to reach the .05 level of significance, were approximately four times more variable than those of females. A similar summarization for deductive-proof answer latency scores is presented in Appendix M. Individual analyses of answer latency variances revealed that treatments associated with delay(s) were less variable than the non-delay treatment.

Appendix N represents the analysis of variance performed on average response latency scores for the eleven easiest items. No statistically significant effects were observed; but, females spent less time responding to questions than did males. The analysis of variance summarized in Appendix O abstracts answer latency data for these easy items. Significant sex and delay of IF effects similar to those obtained for total program items were found in this analysis. Shortest answer latencies were associated with females, and with treatments having immediate IF.

Appendices P and Q summarize mean and variance data respectively for average response and answer latency scores for the eleven easiest items. All individual variance comparisons between response latencies were negligible. However, tests between answer latency variances revealed at the .01 level that female performance was significantly less variable than that of males, and that treatments associated with delayed-feedback were significantly more variable than those associated with immediate-feedback.

Exposure Time Data

Table 9 denotes summarized average exposure time data for total program latency scores. No statistically significant differences were found between the four treatments for response latencies, however, the analysis of answer latency scores revealed that a significantly greater amount of time was spent by Ss examining correct answers when treatments were associated with delayed-feedback. Total average exposure time in seconds for the four treatments was 49.75 for 0-0, 54.56 for 0-8, 59.64 for 8-0 and 67.77 for 8-8. As would be expected, the shortest exposure time was associated with treatment 0-0 and the longest with treatment 8-8.

Intertrial Interval Data

Theoretical and actual intertrial interval exposure time (ITI) for individual treatments is presented in Table 10. Theoretical ITI exposure time for treatment 0-0 was 0 seconds; for 0-8, 8 seconds; for 8-0, 8 seconds; and for 8-8, 16 seconds. However, the actual average ITI for treatment 0-0 was 3.11 seconds; for 0-8, 11.77 seconds; for 8-0, 13.32 seconds; and for 8-8, 20.74 seconds. The average theoretical ITI over all treatments was 8 seconds, whereas the actual average ITI over all treatments due to the confounding of ITI with answer latency was 12.24 seconds.

TABLE 9

Summarized Mean Exposure Time
Data for Program Material*

Treatments	0-0	0-8	8-0	8-8
Total Exposure Time	49.75	54.56	59.64	67.77
Response Latency	46.64	42.79	46.32	47.03
Answer Latency	3.11	3.77	5.32	4.74

*In seconds

Questionnaire Data

The analysis of questionnaire data is presented in Table 11. Ss responses were categorized independently by two judges into behavioral classifications of fatigue (physical), frustration (competing responses) and mediation (task oriented information processing). Examples of representative classifications of responses are presented in Appendix E. There was 95% agreement between the classifications of these judges.

TABLE 10

Summarized Data on Intertrial
Interval Exposure Time*

Treatments	0-0	0-8	8-0	8-8
Theoretical ITI Exposure Time in Seconds	0	8	8	16
Actual Mean Exposure Time as a Function of Confounding ITI with the Answer Latency Variable	3.11	11.77	13.32	20.74

Theoretical Average ITI Equals 8 Seconds

Actual Average ITI was 12.24 Seconds

*In seconds

TABLE 11

Percentage Breakdown of Questionnaire Responses
As a Function of Treatments

Classification of Responses	Treatments 0-0	0-8	8-0	8-8
Fatigue	43 (6) *	0 (0)	7 (1)	7 (1)
Frustration	0 (0)	57 (8)	57 (8)	57 (8)
Mediation	71 (10)	86 (12)	100 (14)	79 (11)

*Each cell is based upon an _n_ of 14. Numbers within parantheses indicate number of _S_s upon which percentage score is based.

DISCUSSION AND CONCLUSIONS

The data led to rejection of the general hypothesis which stated that human learning of complex material would be facilitated by increases in the post-IF interval irrespective of variation in the delay of IF interval, and that the interaction between these delay variables would be negligible. The results show that a simple explanation in terms of the independent effects of delay of IF or post-If is inadequate.

The following decisions were drawn with respect to the statistical error hypotheses. First, the hypothesis that delay of IF in itself would not contribute a significant source of variance was accepted since treatments associated with delayed-IF were not accompanied by significantly larger error scores. This result was inconsistent with much of the literature on delay of reinforcement, but is in agreement with the conclusions of Bourne and Bunderson (1963) and Brackbill and Kappy (1962).

Secondly, the hypothesis that the post-IF variable would contribute a significant source of variance was also rejected in that treatments associated with post-IF delay were not accompanied by significantly lower error scores.

Thus, the present data fail to support Bourne and Bunderson's (1963) supposition that the post-IF interval is a critical variable in human learning. Where Bourne and Bunderson found that increases in the post-IF interval were accompanied by decreases in error scores, the effects of post-IF delay in this experiment were negligible.

The unique result of the present study was the interaction between the delay of IF and post-IF variables. This interaction was found for both complete program and deductive-proof error scores. A similar interaction, although not as pronounced, was also present for criterion error scores.

For all analyses, except that for easy items, where mean error scores were approximately the same, the fewest number of errors was associated with the self-pacing treatment, 0-0; second fewest with the treatment with the longest intertrial interval, i.e., treatment 8-8; third fewest with the treatment 0-8; i.e., the treatment with immediate feedback and an 8 second post-IF delay, and the greatest number of errors with the treatment with delayed feedback and no post-IF delay, i.e., treatment 8-0. The largest variance values for total program items were found with treatments having the greatest number of errors, and the smallest variances with treatments having the fewest number of errors.

Statistically significant differences in error scores for sex or the other interaction effects were not found.

The data obtained in this study are at variance with that reported by Bourne and Bunderson (1963), and by Brackbill and Kappy (1962), in that while the former found a significant post-IF effect, this study did not, and while the latter found no delay of IF effect in agreement with Bourne and Bunderson, this experiment found that there were conditions under which immediate IF did lead to a decrease in error scores.

Both in Bourne and Bunderson's, and the present study, delay of IF and post-IF delay were varied orthogonally. The essential difference between these two studies was that Bourne and Bunderson's tasks were peaked at a constant level of difficulty such that IF could be presented in a fraction of a second (a light flashed on the apparatus) and, as a result, the E completely controlled the ITI. Whereas, in the present study task complexity varied throughout the program and necessitated the use of S, rather than E controlled IF, and consequently, complete E control of the ITI was impossible.

Thus, Bourne and Bunderson's treatments are relatively more massed than are those used in the present study. The effect of massing should be most prevalent in their self-paced treatment, 0-1, and consequently, this treatment should be associated with maximum error scores. Massing

should not occur, however, under self-pacing, such as that used in the present study, where the S controls length of the IF interval. Moreover, the rank order between comparable delay treatment means in Bourne and Bunderson's and the present study should be similar since massing should dissipate when delay or IF and/or post-IF delay is introduced into the experimental situation.

This interpretation was supported by a comparison of comparable treatments between the two studies.[1] Where Bourne and Bunderson found their 0-1 treatment to be associated with the largest number of errors, in the present study the comparable 0-0 treatment produced the fewest number of errors. However, an examination of treatments where delay intervals were similar, revealed identical rank orders for all treatment means except those of easy items. The greatest number of errors was associated with treatment 0-8 (0-9), the second greatest with treatment 8-8 (8-9), and the third greatest with treatment 8-0 (8-1).

Moreover, even though massing per se did not appear to be a crucial factor affecting performance in the present study, 43% of the Ss in the self-paced treatment did complain of physical fatigue due to length of program, whereas 7% or less made similar complaints in each of the delay

---

[1]Bourne and Bunderson's five dimensional concept treatments were used for this comparison. These treatments were chosen since the complexity of these tasks more closely resembled that of the tasks used in the present study, and since Bourne and Bunderson found the post-IF effect to be more pronounced for complex concepts.

treatments. If fatigue due to massing is operating during complete self-pacing, as it appears to be, its influence should be less than that associated with self-pacing in which the E provides IF in a fraction of a second.

The controversial findings between Brackbill and Kappy's (1962) serial learning study, and the present one, can be attributed, in part, to the fact that their Ss always received IF in a fraction of a second (one second to be exact), whereas in this study, Ss did not. Another difference was Brackbill and Kappy's failure to consider the independent effects of delay of IF and post-IF delay. For example, even though they maintained an ITI of 20 seconds between their learning tasks, their immediate-feedback group was accompanied by a 19 second post-IF interval and their delayed-feedback group (10 second delay) by a 9 second post-IF interval. Thus, their immediate and delayed feedback treatments were actually more representative, respectively, of the 0-8 and 8-8 treatments used in the present study. A comparison of their treatments, with the 0-8 and 8-8 treatments of the present study, revealed that the largest number of errors was associated with treatment 0-8 (0-19), and fewest with treatment 8-8 (10-9).

If Brackbill and Kappy had varied their delay variables orthogonally as did Bourne and Bunderson, and had run 0-1 and 8-1 treatments, it is probable that they would have obtained an ordering among their treatment means similar to

Bourne and Bunderson's. If such data were compared with that obtained in the present study, it should differ only with respect to treatment 0-0. And, this difference would be attributable to the fact that the S controlled the feedback interval in the present study, whereas the E would have controlled it in Brackbill and Kappy's study.

Analyses of mean response latency scores for total program and deductive-proof items, revealed that females spend significantly less time, on the average, answering questions (responding to), than did males, and showed less variability in performance. Similar findings, although not as pronounced, were found for easy items. All other null hypotheses were accepted as tenable.

The analyses of mean answer latency scores revealed significant sex and delay of IF effects for total program and easy items, but not for deductive-proof items. Moreover, the data indicated that females spent less time examining correct answers than did males, and that a significantly greater amount of time was spent by Ss examining correct answers when their treatments were associated with delayed, rather than immediate feedback conditions. It appears, that when IF was delayed, that the number of interfering (competing) responses which the S had to process and/or eliminate while examing the correct answer was increased, and that consequently, it was necessary for him to spend more time examining correct answers under delayed, than immediate feedback conditions.

This interference interpretation of delay predicts that as delay increases competing responses will: (1) occur with increasing frequency, (2) lead to an increase in number of errors, and (3) increase the amount of time necessary for the appropriate response to be acquired. The insignificant delay of IF effect associated with deductive-proof items appears to be due to the fact that these items were too complex for the S to process (remember) over delay, and consequently, when IF did occur, the S could not remember his original response ergo he just moved on to the next frame.

Additional support for this interference interpretation of delay was obtained in the analyses of main effect variances where the data revealed, for both total program and easy items, that performance was significantly more variable under delayed than under immediate feedback conditions. This finding was reversed, however, for the analyses of deductive-proof variances where treatments associated with delay(s) were found to be less variable than the non-delay treatment. It appears that Ss were not overwhelmed by the differential complexity of tasks within the total program per se, but that they were when the effects of deductive-proof items were considered alone. Thus, the data for total program items indicates that Ss remembered their responses over delay when tasks were not to complex, and that Ss increased the length of the feedback interval

when necessary, to determine where they had made a particular error. However, when tasks were extremely complex, as they were for deductive-proof items, it appears that there was too much information for Ss to remember over delay, and that consequently, when IF did occur, they just moved on to the next task without trying to figure out where or why they had made a particular error.

Further support for this interference interpretation was obtained from the analysis of the general information questionnaire. The questionnaire revealed that 57% of the Ss in each of the delay treatments complained of frustration while working through the program. It appears that competing responses were initiated during delay, that these responses were overtly characterized in terms of frustration, and that Ss were able to use the IF interval to process and/or eliminate many of these competing responses. Moreover, it appears that if delay of IF had been extended to the point where Ss could no longer cope with these competing responses, that a significant delay of IF effect would have emerged.

Similar competing response interpretations of delay have been formulated by Spence (1960) and Denny and Adelman (1955) for animal learning, and by Denny for human learning.[2] These Es surmised, as does the present paper, that delay elicits competing responses which are overtly characterized

---

[2]Personal communication with M.R. Denny. Michigan State University, East Lansing, Michigan, Fall, 1964.

by frustration, that these responses become conditioned to the same stimuli as does the to-be-learned response, and that acquisition time increases as a function of increments in the delay variable. Consequently, such theories predict maximal learning to be associated with immediate feedback conditions.

This competing response interpretation of delay explains the individual treatment effects obtained in the present study. As would be expected, the self-paced treatment, 0-0, where delay was absent, was characterized by the fewest number of errors, and by shorter answer latency scores. Further, the questionnaire revealed that Ss in this treatment were not bothered by frustration (competing responses) while working through the program. But, it did show that 43% of the Ss in the self-paced treatment complained of physical fatigue due to length of program, whereas 7% or less made similar complaints in the treatments associated with delay(s).

It appears that competing behavior was minimized under self-pacing, and that massing, rather than length of program was responsible for the fatigue effect in treatment 0-0, since for all practical purposes the effect disappeared when delay was introduced. Although the questionnaire also revealed that 71% of the Ss gave responses indicating that they were actively involved (mediating) while working through the program, the data is somewhat misleading when compared

with that obtained for delayed treatments since forced delays were not common to this treatment. However, the data of the self-paced treatment did show, when compared with that obtained for delayed treatments, that when delays are not indiscriminately forced upon Ss, that Ss vary delay as a function of need, and that mediation still plays an important role in acquisition.

In the treatment associated with the second fewest number of errors, i.e., treatment 8-8, Ss spent a significantly greater amount of time examining correct answers than they did under the self-paced treatment. The questionnaire revealed that 79% of these Ss were actively processing information during delay, and that, whereas Ss did not show signs of frustration under self-pacing, that 57% of the Ss in this treatment did. These findings indicated that Ss needed and used the IF interval to eliminate competing responses which had developed during delay of IF, and that the post-IF interval allowed Ss to further process feedback information by minimizing competing behavior which would have occurred with the immediate presentation of the next frame. A secondary facet contributing to the effectiveness of treatment 8-8 was its association with the longest ITI, and consequently, with longest total program exposure time.

The analysis of questionnaire data for the treatment associated with the third fewest number of errors, i.e., treatment 0-8, revealed that 86% of these Ss were processing

information during the post-IF interval, and that 57% of these Ss complained of frustration while working through the program. It appears that even though competing responses were minimized by immediate IF, that Ss were not able to eliminate competing responses which occurred during post-IF delay, since they were not able to return to the original question or the correct answer, and that the presentation of additional frames led to an increment in the number of competing responses already present, and consequently, to an increase in error scores.

The data associated with the treatment with the greatest number of errors, i.e., treatment 8-0, indicated that Ss spent a significantly greater amount of time examining correct answers under this treatment than they did under treatments associated with immediate feedback. The questionnaire showed that all (100%) Ss were actively involved (mediating) during acquisition, and that 57% of these Ss complained of frustration. These findings indicated as did those for treatment 8-8, that Ss needed, and used, the IF interval to eliminate competing responses elicited during the delay of IF interval.

However, the data for treatment 8-0 also indicated that the immediate presentation of the next frame, after IF, was conducive to the development of additional competing responses, since, this treatment was associated with maximum error scores and differed from treatment 8-8 only in that it

lacked the 8 second post-IF interval. It appears that competing responses associated with the immediate presentation of the next frame combine with those already developed, and that therefore, error scores reach a maximum under this treatment. Although both Ramond (1954) and Renner (1963) have found support in animal research for such an additive inhibitory effect due to failure on behalf of Ss to minimize competing responses, this problem has yet to be extensively investigated with humans.

In summary, the data led to the rejection of the general hypothesis which stated that human learning of complex material would be facilitated by increases in the post-IF interval irrespective of variations in delay of IF, and that the interaction between these delay variables would be negligible. The results show that a simple explanation in terms of the independent effects of delay of IF or post-IF is inadequate. Fewest number of errors was associated with the self-paced treatment 0-0, second fewest with treatment 8-8, third fewest with treatment 0-8, and the greatest number of errors with treatment 8-0.

As predicted, all delay effects for response latencies were insignificant. However, the analyses of answer latencies revealed that Ss spent a greater amount of time examining correct answers when treatments were associated with delayed-IF. A competing response interpretation of delay was

formulated with respect to error scores, answer latencies and the delay variables.

Moreover, it appears that self-pacing with immediate reinforcement increases the probability of a desired form of behavior, that delay of IF and/or post-IF delay initiates frustrative behavior which interferes with acquisition, and that, post-IF delay is not a crucial variable in complex human learning (programed) unless it is accompanied by delayed-IF.

B I B L I O G R A P H Y

BIBLIOGRAPHY

Adelman, H.M., and Maatsch, J.L. Resistance to Extinction As a Function of the Type of Response Elicited by Frustration. J. Exp. Psychol., 1955, 50, 61-65.

Ammons, R.B. Effects of Knowledge of Performance: A Survey and Tentative Theoretical Formulation. J. Gen. Psychol., 1956, 54, 279-299.

Amsel, A. Drive Properties to the Anticipation of Frustration. Psycyol. Bull., 1958, 55, 102-119.

Angell, G.W. The Effect of Immediate Knowledge of Quiz Results on Final Examination Scores in Freshman Chemistry. J. Educ. Res., 1949, 42, 391-394.

Becker, P.W., Mussina, C.M., and Persons, R.W. Intertrial Interval, Delay of Knowledge of Results, and Motor Performance. Percept. Mot. Skills, 1963, 17, 559-563.

Bilodeau, E.A., and Bilodeau, I. McD. Variation of Temporal Intervals Among Critical Events in Five Studies of Knowledge of Results. J. Exp. Psychol., 1958, 55, 603-612.

Bilodeau, E.A., and Ryan, F.J. A Test for Interaction of Delay of Knowledge of Results and Two Types of Interpolated Activity. J. Exp. Psychol., 1960, 59, 414-419.

Bourne, L.E., Jr. Effects of Delay of Information Feedback and Task Complexity on the Identification of Concepts. J. Exp. Psychol., 1957, 54, 201-207.

Bourne, L.E. and Bunderson, C.V. Effects of Delay of Informative Feedback and Length of Postfeedback Interval on Concept Identification. J. Exp. Psychol., 1963, 65, 1-5.

Brackbill, Y. The Impairment of Learning Under Immediate Reinforcement. Unpublished paper, University of Colorado Medical Center, 1964.

Brackbill, Y., and Kappy, M.S. Delay of Reinforcement and Retention. J. Comp. Physiol. Psychol., 1962, 55, 14-18.

Brown, J.S. A Proposed Program of Research on Psychological Feedback (Knowledge of Results) In the Performance of Psychomotor Tasks. In Research Planning Conference on Perceptual and Motor Skills. San Antonio, Texas: Hum. Resour. Res. Cent., Lackland A.F.B., 1949. (Conf. Rep. 49-2), 81-87.

Carlton, P.L. Response Strength as a Function of Delay of Reward and Physical Confinement. Unpublished Master's Thesis, University of Iowa, 1954.

Coulson, J.E., and Silberman, H. Results of an Initial Experiment in Automated Teaching. J. Ed. Psychol., 1960, 51, 135-143.

Denny, M.R., and Adelman, H.M. Elicitation Theory: 1. An Analysis of Two Typical Learning Situations. Psychol. Rev., 1955, 62, 290-296.

Denny, M.R., et al. Supplementary Report: Delay of Knowledge of Results, Knowledge of Task, and Intertrial Interval. J. Exp. Psychol., 1960, 60, 327.

Erickson, M., and Lipsitt, L.P. Effects of Delayed Reward On Simultaneous and Successive Discrimination Learning in Children. J. Comp. Physiol. Psychol., 1960, 53, 256-260.

Evans, J.L. An Investigation of "Teaching Machine" Variables Using Learning Programs in Symbolic Logic. Unpublished Doctoral Dissertation, University of Pittsburgh, 1960.

Evans, J.L., Glaser, R., and Homme, L.E. An Investigation of "Teaching Machine" Variables Using Learning Programs in Symbolic Logic. J. Ed. Res., 1962, 55, 433-452.

Evans, J.L., Homme, L.E., and Glaser, R. The Ruleg System For the Construction of Programmed Verbal Learning Sequences. J. Ed. Res., 1962, 55, 515-520.

Feldhusen, J.F., Ramharter, H., and Birt, A.T. The Teacher vs. Programed Learning. Wis. J. Ed., 1962, 95, 8-10.

Gr

G

H

Greenspoon, J., and Foreman, S. Effect of Delay of Knowledge of Results on Learning a Motor Task. J. Exp. Psychol., 1956, 51, 226-228.

Guthrie, E.R. The Psychology of Learning. (Rev. Ed.), New York: Harper and Bros., 1952.

Harker, G.S. An Experimental Investigation of the Effects of Changes in the Delay of Reinforcement Upon Level of Performance of an Instrumental Response. Unpublished Doctoral Dissertation, University of Iowa, 1950.

Hough, J.B., and Revsin, B. Programed Instruction at the College Level: A Study of Several Factors Influencing Learning. Phi Delta Kappan., 1963, 44, 286-291.

Hull, C.L. Principles of Behavior. New York: Appleton-Century-Crofts, 1943.

Kanner, J.H., and Sulzer, R.L. Overt and Covert Rehearsal of Fifty Per Cent vs. Hundred Per Cent of the Material in Film Learning. In A.A. Lumsdaine, (Ed.) Student Response in Programed Instruction: A Symposium on Experimental Studies of Cue and Response Factors in Group and Individual Learning From Instructional Media. Sponsored by Headquarters, Air Research and Development Command, U.S. Air Force. Washington, D.C.: National Academy of Sciences, National Research Council, 1961, 427-441.

Kromboltz, J.D., and Bonawitz, B. The Effect of Receiving the Confirming Response in Context in Programed Material. J. Ed. Res., 1962, 55, 472-475.

Lorge, I., and Thorndike, E.L. The Influence of Delay in Affect-Effect of a Connection. J. Exp. Psychol., 1935, 18, 187-194.

Lumsdaine, A.A. The Development of Teaching Machines and Programmed Self-Instruction. New Teaching Aids for the American Classroom. Stanford University: The Institute for Communication Research, 1960, 136-173.

McDonald, F.J., and Allen, D. An Investigation of Presentation Response, and Correction Factors in Programed Instruction. J. Ed. Res., 1962, 55, 502-507.

McGuigan, E.J. The Effect of Precision, Delay, and Schedule of Knowledge of Results on Performance. J. Exp. Psychol., 1959, 58, 79-84.

Meyer, S.R. Report on the Initial Test of a Junior High School Vocabulary Program, 1960. In A.A. Lumsdaine and R. Glaser (Eds.), Teaching Machines and Programmed Learning. Washington, D.C.: National Education Association of the United States, 1960, 229-246.

Moore, J.W., and Smith, W.I. Knowledge of Results in Self-Teaching Spelling. Psychol. Rep., 1961, 9, 717-726.

Mowrer, O.H. Learning Theory and Behavior. New York: Wiley, 1960.

Noble, C.E., and Alcock, W.T. Human Delayed-Reward Learning with Different Lengths of Task. J. Exp. Psychol., 1958, 56, 407-412.

Pubols, B.H. Delay of Reinforcement, Response Preservation, and Discrimination Reversal. J. Exp. Psychol., 1958, 56, 32-40.

Ramond, C.K. Performance in Instrumental Learning as a Joint Function of Delay of Reinforcement and Time of Deprivation. J. Exp. Psychol., 1954, 47, 248-250.

Renner, K.E. Delay of Reinforcement: A Historical Review. Psychol. Bull., 1964, 61, 341-361.

Renner, K.E. Influence of Deprivation and Availability of Goal Box Cues on the Temporal Gradient of Reinforcement. J. Comp. Physiol. Psychol., 1963, 56, 101-104.

Rieber, M. The Effect of CS Presence During Delay and Reward on the Speed of an Instrumental Response. J. Exp. Psychol., 1961, 61, 290-294.

Ryan, F.J., and Bilodeau, E.A. Countertraining of a Simple Skill with Immediate and 1-Week Delays of Information Feedback. J. Exp. Psychol., 1962, 63, 19-22.

Saltzman, I.J. Delay of Reward and Human Verbal Learning. J. Exp. Psychol., 1951, 41, 437-439.

Saltzman, I.J. Kanfer, F.H., and Greenspoon, J. Delay of Reward and Human Motor Learning. Psychol. Rep., 1955, 1, 139-142.

Sheffield, F.D., *et al*. Drive Reduction *versus* Consummatory Behavior as Determinants of Reinforcement. *J. Comp. Physiol. Psychol*., 1954, *47*, 349-354.

Shilling, M. An Experimental Investigation of the Effect of a Decrease in the Delay of Reinforcement Upon Instrumental Response Performance. Unpublished Master's Thesis, University of Iowa, 1951.

Skinner, B.F. *The Behavior of Organisms*. New York: Appleton-Century-Crofts, 1938.

Skinner, B.F. The Science of Learning and the Art of Teaching. *Harvard Ed. Rev*., 1954, *24*, 86-97.

Spence, K.W. *Behavior Theory and Conditioning*. New Haven: Yale University Press, 1956.

Spence, K.W. *Behavior Theory and Learning*. Englewood Cliffs, New Jersey: Prentice-Hall, 1960.

Tolman, E.C. Principles of Performance. *Psychol. Rev*., 1955, *62*, 315-325.

Wolfle, D. Training. In S.S. Stevens (Ed.), *Handbook of Experimental Psychology*. New York: Wiley, 1951.

A P P E N D I C E S

APPENDIX A

Rules Covered in the Programed Material

Wedge Adding (WA)

1. a
2. $a \vee b$ (any letter) WA 1

Wedge Identity (WI)

1. $a \vee a$
2. a WI 1

Spear Separation (SS)

1.	$a \rightarrow b$			1.	o
2.	a		<u>or</u>	2.	$o \rightarrow p$
3.	b	SS 1,2		3.	p SS 2,1

Tent Jointing (TJ)

1. z
2. a
3. $z \wedge a$ TJ 1,2 <u>or</u> $a \wedge z$ TJ 2,1

Tent Disconnecting (TD)

1. $a \wedge b$
2. a TD 1

Double Spear (DS)

1.	$a \rightarrow b$			1.	$c \rightarrow d$
2.	$b \rightarrow c$		<u>or</u>	2.	$b \rightarrow c$
3.	$a \rightarrow c$	DS 1,2		3.	$b \rightarrow d$ DS 2,1

Letter Exchange (LE)

1.	$a \wedge b$		<u>or</u>	1.	$a \vee b$
2.	$b \wedge a$	LE 1		2.	$b \vee a$ LE 1

APPENDIX B

Instructions Given to Subjects

You are about to learn some material by the method of programed instruction. Your task is to answer each question to the best of your ability from the material which you have learned. Please write down your answer on the paper provided. When you have answered the question press the button and wait for the correct answer to appear. This will enable you to see whether or not you have made a correct response. When you have finished checking the correctness of your answer press the button again and wait for the next question to appear.

If you have any questions please ask them now. You will receive a short break mid-way through the program. Now press the button and begin.

APPENDIX C

Examples of Criterion Test Items

The following examples show the instruction to Ss and three sample items from each of the subtests.

True-False Test

In the following examples circle "T" if the LAST step is a correct example of the rule indicated. If it is an incorrect example, circle "F".

T F 1. $g \rightarrow h$
2. g
3. g SS 1,2 (Spear Separation)

T F 1. $a \rightarrow b$
2. x
3. $b \rightarrow c$
4. $a \rightarrow c$ DS 1,3 (Double Spear)

T F 1. $b \rightarrow b$
2. $a \vee a$
3. b WI 2 (Wedge Identity)

Recall Test

Solve the following problems by using the rule given at the LAST step of each example.

1. $a \vee e$
2. LE 1 (Letter Exchange)

1. z
2. a
3. TJ 2,1 (Tent Joining)

1. $a \rightarrow b$
2. $c \rightarrow a$
3. DS 2,1 (Double Spear)

Deductive-Proof Test

In the following problems, use any rules that you want in any order that you want and as often as you want to get to the Winning Step or "W". Do not spend too much time on any one problem. You may go back and work on an incomplete problem later. Complete as much of each problem as you can. Do NOT forget rule initials and step numbers.

1. $x \rightarrow r$
2. x / W: $r \vee k$

1. $a \wedge b$ / W: b

1. $m \rightarrow n$
2. $n \rightarrow o$
3. x / W: $x \wedge \underline{m \rightarrow o}$

APPENDIX D

General Information Questionnaire

The following questions are those used in the general information questionnaire.

Instructions to S:

Please answer the following questions to the best of your ability. Do NOT be afraid to state your true impressions of the experiment.

1. What did you find yourself thinking about and/or doing after making a correct response while waiting for the next frame to appear?

2. What did you find yourself thinking about and/or doing after making an incorrect response while waiting for the next frame to appear?

3. Write down any comments which you might have on this experiment.

APPENDIX E

Representative Classifications of Responses for Questionnaire Data

Fatique:	"It seemed to get tedious towards the end."
	"I kept thinking, 'When will it ever be finished?'"
	"I felt somewhat discouraged and became aware of my tiredness towards the end."
	"Possibly the program was about ten minutes too long."
Frustration:	"I wished the machine would hurry up--it was frustrating when you had to wait."
	"It was somewhat confusing as the rules multiplied."
	"I found myself wishing I had a reference to all the rules in relation to each other at one time for study."
	"I often thought of unrelated things while waiting for the next frame to occur."
Mediation:	"I kept going over in my mind the steps I had used to arrive at the answer."
	"I tried to think where I went wrong during the delay so that next time I would not make the same error."
	"I kept trying to remember the method I used for future problems."
	"I found myself rehearsing when I had to wait."

APPENDIX F

Analysis of Variance on Error Scores for the Deductive-Proof Items

Source	DF	F
Sex	1	.018
Delay of IF (DIF)	1	1.310
Postfeedback Interval (PIF)	1	.000
Sex X DIF	1	.080
Sex X PIF	1	.012
DIF X PIF	1	4.372*
Sex X DIF X PIF	1	.031
Residual MS	48	(5.02)

*$p < .05$

APPENDIX G

Analysis of Variance on Error Scores for the Eleven Easiest Items

Source	DF	F
Sex	1	.877
Delay of IF (DIF)	1	2.013
Postfeedback Interval (PIF)	1	.211
Sex X DIF	1	1.628
Sex X PIF	1	2.093
DIF X PIF	1	.318
Sex X DIF X PIF	1	1.494
Residual MS	48	(.62)

APPENDIX H

Summarized Mean and Variance Data for Error Scores on the Deductive-Proof Items

Source	N	Mean	Variance
Male	28	3.24	4.50
Female	28	3.32	5.54
0-0	14	2.31	4.67
0-8	14	3.56	4.60
8-0	14	4.25	5.90
8-8	14	2.99	4.90
DIF-0	28	2.94	4.63
DIF-8	28	3.63	5.40
PIF-0	28	3.28	5.28
PIF-8	28	3.28	4.75

APPENDIX I

Summarized Mean and Variance Data for Error Scores on the Eleven Easiest Items

Source	N	Mean	Variance
Male	28	.78	.88
Female	28	.59	.35
0-0	14	.43	.25
0-8	14	.65	.49
8-0	14	.85	1.14
8-8	14	.82	.91
DIF-0	28	.54	.37
DIF-8	28	.83	1.03
PIF-0	28	.64	.70
PIF-8	28	.73	.70

APPENDIX J

Analysis of Variance on Average Response Latency Scores for the Deductive-Proof Items

Source	DF	F
Sex	1	5.077*
Delay of IF (DIF)	1	.228
Postfeedback Interval (PIF)	1	.029
Sex X DIF	1	.612
Sex X PIF	1	2.631
DIF X PIF	1	1.130
Sex X DIF X PIF	1	.002
Residual MS	48	(689.07)

*$p < .05$

APPENDIX K

Analysis of Variance on Average Answer Latency Scores for the Deductive-Proof Items

Source	DF	F
Sex	1	.655
Delay of IF (DIF)	1	2.007
Postfeedback Interval (PIF)	1	.048
Sex X DIF	1	.341
Sex X PIF	1	3.880
DIF X PIF	1	.415
Sex X DIF X PIF	1	.407
Residual MS	48	(22.87)

APPENDIX L

Summarized Mean and Variance Data for Average Response Latency Scores on the Deductive-Proof Items

Source	N	Mean	Variance
Male	28	90.95	1160.70
Female	28	75.14	217.43
0-0	14	84.51	322.26
0-8	14	78.23	827.39
8-0	14	80.40	544.43
8-8	14	89.04	1062.19
DIF-0	28	81.37	574.82
DIF-8	28	84.72	803.31
PIF-0	28	82.45	433.35
PIF-8	28	83.64	944.79

APPENDIX M

Summarized Mean and Variance Data for Average Answer Latency Scores on the Deductive-Proof Items

Source	N	Mean	Variance
Male	28	9.58	17.55
Female	28	8.54	28.15
0-0	14	7.89	50.43
0-8	14	8.43	10.16
8-0	14	10.52	15.50
8-8	14	9.42	15.42
DIF-0	28	8.16	30.29
DIF-8	28	9.97	15.46
PIF-0	28	9.20	32.96
PIF-8	28	8.92	12.79

APPENDIX N

Analysis of Variance on Average Response Latency Scores for the Eleven Easiest Items

Source	DF	F
Sex	1	3.970
Delay of IF (DIF)	1	1.824
Postfeedback Interval (PIF)	1	.167
Sex X DIF	1	1.567
Sex X PIF	1	.720
DIF X PIF	1	.832
Sex X DIF X PIF	1	.080
Residual MS	48	(7.74)

APPENDIX O

Analysis of Variance on Average Answer Latency Scores for the Eleven Easiest Items

Source	DF	F
Sex	1	4.369*
Delay of IF (DIF)	1	9.440**
Postfeedback Interval (PIF)	1	.084
Sex X DIF	1	.685
Sex X PIF	1	.159
DIF X PIF	1	1.696
Sex X DIF X PIF	1	.944
Residual MS	48	(1.20)

*$p < .05$

**$p < .01$

APPENDIX P

Summarized Mean and Variance Data for Average Response Latency Scores on the Eleven Easiest Items

Source	N	Mean	Variance
Male	28	10.88	6.48
Female	28	9.40	9.00
0-0	14	10.13	7.72
0-8	14	9.15	8.49
8-0	14	10.46	5.79
8-8	14	10.83	8.96
DIF-0	28	9.64	8.11
DIF-8	28	10.64	7.37
PIF-0	28	10.29	6.75
PIF-8	28	9.99	8.72

APPENDIX Q

Summarized Mean and Variance Data for Average Answer Latency Scores on the Eleven Easiest Items

Source	N	Mean	Variance
Male	28	1.90	2.13
Female	28	1.28	.26
0-0	14	1.01	.12
0-8	14	1.27	.26
8-0	14	2.29	2.57
8-8	14	1.79	1.84
DIF-0	28	1.14	.19
DIF-8	28	2.04	2.20
PIF-0	28	1.65	1.35
PIF-8	28	1.53	1.05