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Variable Reinforcement Schedules on a Teacher-Constructed Test

Michael Stephen Palanuk
Central Washington University

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VARIABLE REINFORCEMENT SCHEDULES ON A
TEACHER-CONSTRUCTED TEST

A Thesis
Presented to
the Graduate Faculty
Central Washington State College

In Partial Fulfillment
of the Requirements for the Degree
Master of Education

by
Michael Stephen Palanuk
August, 1967
APPROVED FOR THE GRADUATE FACULTY

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Daryl Basler, COMMITTEE CHAIRMAN

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Donald G. Goetschius

______________________________
Darwin J. Goodey
ACKNOWLEDGMENT

Grateful acknowledgment is extended to Dr. Daryl Basler for his encouragement and direction, and to Dr. Donald Goetschius and Mr. Darwin Goodey for their helpful comments and timely suggestions.

A sincere thank you is given to Donald Whitcraft, counselor at Tahoma Junior High School, for his assistance in administration of the experimental tests.

Also, a special thanks to my wife for her support and diligent deciphering performance at the typewriter.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. THE PROBLEM AND DEFINITIONS OF TERMS</td>
<td>1</td>
</tr>
<tr>
<td>The Problem</td>
<td>2</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>2</td>
</tr>
<tr>
<td>Definitions of Terms</td>
<td>2</td>
</tr>
<tr>
<td>Learning</td>
<td>2</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>2</td>
</tr>
<tr>
<td>Teacher-constructed test</td>
<td>3</td>
</tr>
<tr>
<td>Grade point average</td>
<td>3</td>
</tr>
<tr>
<td>Hypotheses to be Tested</td>
<td>4</td>
</tr>
<tr>
<td>Organization of the Thesis</td>
<td>5</td>
</tr>
<tr>
<td>II. REVIEW OF THE LITERATURE</td>
<td>6</td>
</tr>
<tr>
<td>Conclusions Reached From Animal Studies</td>
<td>6</td>
</tr>
<tr>
<td>Investigations of Human Learning</td>
<td>7</td>
</tr>
<tr>
<td>Motor Skills investigations</td>
<td>7</td>
</tr>
<tr>
<td>Discrimination learning</td>
<td>8</td>
</tr>
<tr>
<td>Conceptual learning</td>
<td>9</td>
</tr>
<tr>
<td>Summary</td>
<td>11</td>
</tr>
<tr>
<td>III. METHODS AND PROCEDURES</td>
<td>12</td>
</tr>
<tr>
<td>Population and Sample</td>
<td>12</td>
</tr>
<tr>
<td>Procedures of the Study</td>
<td>12</td>
</tr>
<tr>
<td>Matching procedures</td>
<td>12</td>
</tr>
<tr>
<td>Preparation of subjects for the test</td>
<td>14</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>PAGE</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Description of the test</td>
<td>14</td>
</tr>
<tr>
<td>Testing orientation</td>
<td>15</td>
</tr>
<tr>
<td>Session 1</td>
<td>15</td>
</tr>
<tr>
<td>Session 2</td>
<td>16</td>
</tr>
<tr>
<td>Session 3</td>
<td>17</td>
</tr>
<tr>
<td>Analysis of Data</td>
<td>17</td>
</tr>
<tr>
<td>IV. STATISTICAL RESULTS OF THE TEST</td>
<td>18</td>
</tr>
<tr>
<td>V. DISCUSSION AND RECOMMENDATIONS</td>
<td>23</td>
</tr>
<tr>
<td>Discussion</td>
<td>23</td>
</tr>
<tr>
<td>Delayed and nonreinforcement group comparisons</td>
<td>23</td>
</tr>
<tr>
<td>Immediate and nonreinforcement group comparisons</td>
<td>23</td>
</tr>
<tr>
<td>Immediate and delayed reinforcement group comparisons</td>
<td>24</td>
</tr>
<tr>
<td>Recommendations</td>
<td>25</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>28</td>
</tr>
<tr>
<td>APPENDIX A. Sample Factual and Reasoning Test Questions</td>
<td>34</td>
</tr>
<tr>
<td>APPENDIX B. Reinforcement Schedule for Factual and Reasoning Subtests</td>
<td>36</td>
</tr>
</tbody>
</table>
### LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Factual Subtest: Group Comparisons of Individual Subjects' Difference Scores (Session 3 Minus Session 1)</td>
<td>20</td>
</tr>
<tr>
<td>II. Reasoning Subtest: Group Comparisons of Individual Subjects' Difference Scores (Session 3 Minus Session 1)</td>
<td>21</td>
</tr>
<tr>
<td>III. Total Test: Group Comparisons of Individual Subjects' Difference Scores (Session 3 Minus Session 1)</td>
<td>22</td>
</tr>
<tr>
<td>IV. Factual Question Schedule with Time in Seconds</td>
<td>36</td>
</tr>
<tr>
<td>V. Inductive Question Schedule with Time in Seconds</td>
<td>37</td>
</tr>
</tbody>
</table>
CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS

Few persons doubt that teacher-constructed tests plus knowledge of results are learning devices in the educational process, but as of late, experimentation has attempted to determine how the timing of reinforcement affects human learning. It has almost become an educational truism to state that answers to test questions should be known by students as soon as possible after a test is administered. This statement is based largely on generalizations derived from the results of experiments done with animals such as rats and pigeons.

This study was motivated by recent information indicating that delayed rather than immediate knowledge of results could facilitate learning of academic material. This idea is centered on the study done by Sturges and Crawford (51:1-32) which casts doubt on the necessity for immediate knowledge of results with human subjects. This study will be examined more fully in the following chapter.
I. THE PROBLEM

Statement of the problem. The purpose of this study was to investigate timing of reinforcement and its relationship to performance on a teacher-constructed test. More specifically, it was concerned with the extent that reinforcement timing influenced learning of seventh grade general science material in physical geology.

The results of this study appear to have implications for public school teachers and administrators toward understanding the relationship between timing and reinforcement regarding teacher-constructed tests.

II. DEFINITIONS OF TERMS

Learning. In this paper the term "learning" indicates acquisition of knowledge relative to correct answers to questions on a teacher-constructed, multiple-choice test. Learning was measured by comparing each subject's score during session one (the test for placement) and his score during session three (the test for retention after reinforcement).

Reinforcement. The term "reinforcement" means the indication to the subject of the correct answer to a test question. It shall also be referred to as knowledge of results or KR. During this study there were three levels
of reinforcement: (1) immediate reinforcement--reinforcement given immediately after the subject selected what he felt to be the correct answer to a test question; (2) delayed reinforcement--reinforcement given twenty-four hours after testing; and (3) non-reinforcement--total lack of knowledge of results during the investigation.

The term "reinforcement" as used in studies utilizing animals, refers to the presentation of food for a correct response. Generally, the animals had been deprived of food for twelve to twenty-four hours before these studies and are therefore "motivated" to perform the response desired once oriented to the task.

Teacher-constructed test. A "teacher-constructed test" is designated as a test constructed by the teacher which is representative of the material studied. This particular test contained items of difficulty for higher ability students, items within the capabilities of lower ability students, and items the middle range or "average" student would find easy, of moderate difficulty, and difficult.

Grade point average. A subject's grade point average shall be interpreted as meaning his academic average on a thirteen point scale for the four academic subjects: (1) language arts, (2) general science, (3) mathematics, and
(4) social studies offered at the subject's school. The thirteen point grade scale was based on discrete numbers ranging from an "A+" which was equal to twelve, to an "F" which was equal to zero. Grade point averages were determined for each subject by averaging the previous year's grades and his first semester grades for the present school year.

III. HYPOTHESES TO BE TESTED

Hypotheses tested in this study pertain to the examination of three levels of reinforcement experienced by the subjects after taking a teacher-constructed test. Specifically, these are:

1. There will be no difference between those students who receive delayed knowledge of results and those who receive no reinforcement on a teacher-constructed test.

2. There will be no difference in learning between students who receive immediate knowledge of results and those who receive no reinforcement on a teacher-constructed test.

3. There will be no difference in learning between students who receive immediate knowledge of results and students who receive delayed knowledge of results on a teacher-constructed test.
IV. ORGANIZATION OF THE THESIS

To this point, the first chapter has presented a statement of the problem, a definition of terms, and the hypotheses to be tested. The following chapter will review literature concerning research performed to date on variable reinforcement schedules with human subjects. The third chapter will present in detail the procedures followed in this particular experiment, including the population sample, matching technique, and experimental design. The two remaining chapters will present the results with statistical analysis and a summary with the recommendations implied by the results of the study.
CHAPTER II

REVIEW OF THE LITERATURE

This chapter presents an overview of the investigations done in variable reinforcement learning with animals. Furthermore, it reviews studies done with human subjects in motor skills tasks, discrimination learning, and conceptual learning.

I. CONCLUSIONS REACHED FROM ANIMAL STUDIES

The majority of studies testing variable reinforcement schedules have involved animals such as rats and pigeons. Rats are a logical tool of the researcher due to their relatively short gestation period and limited experience, which does not interfere with learning during an experiment. Similarly, pigeons are selected for their naivety and possibly higher mental abilities than rats.

According to Renner, W. S. Hunter designed the first experiment to test delayed reinforcement with rats (42:341). In the 54 years following that experiment, scientists have determined that delay of reinforcement with animal subjects decreases response speed, increases errors, and increases trials to criteria (42:353-354).

In addition, upper limits of delay for both rats and pigeons have been determined. For rats the upper limit of
delay for observable learning to take place is twenty seconds (39:50). For pigeons this upper limit has been established at sixty seconds (20:221; 37:367). Wike has also determined that there is little doubt that delay increases resistance to extinction in rats (54:481).

In discussing laboratory animal findings, Renner states:

The important comparative question is whether the basic generalizations available from animal experiments also apply to human learning situations (42:355). Regardless of this question, results of these studies and similar studies form the basis for teaching machine theory, which proceeds on the assumption that the more immediate the reinforcement, the faster the acquisition of material (23:147-148). These animal studies, then, form the background for this investigation of the effects of delayed reinforcement with humans.

II. INVESTIGATIONS OF HUMAN LEARNING

Experiments with human learning have involved human motor skills, discrimination learning, and concept learning. Motor Skills Investigations

According to Sturges and Crawford, "As far as the type of response is concerned, the most analogous learning situation for humans would be one of motor skills" (51:3).
Typical studies of motor skills learning have examined line drawing, throwing a ball, and knob turning.

A study by Denney, et al. (17:327) utilizing blindfolded subjects drawing a line of a certain length with zero, ten, and twenty second KR, found a significant difference for the zero and ten second delay situations in comparing them with the twenty second delay situation \( (P < .001) \). However, Lorge and Thorndike's study raised a question relative to the effect of reinforcement schedules on tests of motor skills. They found that immediate quantitative KR produced no better skill in tossing a ball at an unseen target than did delays of up to six seconds (34:193).

Moreover, the Bilodeaus' study (4:381) involving five experiments in turning a knob to a pre-selected position found increased facility with twenty-four hour KR delay in one experiment. Their other experiments, which investigated delays ranging from three seconds to seven days, produced no significant differences.

**Discrimination Learning**

In discrimination learning, there is also disagreement about the effect of delayed reinforcement on the acquisition of material. In a discrimination task study, Hockman and Lipsitt (22:24-27) found that increases in delay of KR produced significantly less learning \( (P < .001) \). The task
studied was the selection of a button that corresponded to the correct colored stimulus light on a three-light panel. This study investigated zero, ten, and thirty second delays of KR.

In a similar study by Etzel and Wright (18:281-293) with an identical reinforcement schedule but different colored stimulus lights, no difference was found. In both of these studies no difference was noted between the stimulus colors within each study, but no comparison can be made between the colors used in the two studies.

In a study by Landsman (28:66) involving discrimination of four digit numbers in comparing immediate to six second delays, there was a significant facility acquired with delay.

Conceptual Learning

As with motor skills and discrimination tasks, there is little agreement on the effect of immediate versus delayed reinforcement in conceptual learning. Angell's study (1:391-394) on the effect of immediate and delayed knowledge of results on quizzes during the college school year compared with final examination scores is typical of the few studies done with course content learning. It supports immediate reinforcement, but appears to have limitations.

The groups were not reinforced by the same procedure, i.e., punchboards were used for initial reinforcement with
the immediate KR group and corrected test return and review were used for reinforcement with delayed KR group. In addition, the immediate KR group was in effect reinforced twice: first after punching their answers, and second by reviewing the results of their quiz performance. The delayed KR group received a single reinforcement, the test review with corrections.

In a study by Sturges and Crawford, delayed reinforcement was found to be superior to immediate reinforcement in two of four experiments. The delayed group was significantly superior to immediate reinforcement with factual and inductive questions, but there was no significant difference between the immediate and delayed groups on the nonsense and inductive-with-cue experiments. In addition, both groups were superior to the nonreinforcement group on all four experiments (51:13-16).

One difference between the study by Sturges and Crawford and the previously discussed experiment by Angell was the use of test material unfamiliar to the subjects. The results imply that the subjects did learn from the test if given KR; therefore, a test is a teaching instrument. However, there was no difference in learning between the delayed and immediate reinforcement groups on this portion of the study.
Also incorporated in the above study to determine if the delayed KR group was at an advantage over the immediate KR group due to massed versus distributed practice, the non-reinforcement group was exposed to the test material twice before the test for retention. There was no significant difference in learning shown by the nonreinforcement group (51:20).

III. SUMMARY

In general, this review of the literature pertinent to reinforcement schedules with animals has shown that learning is affected negatively as to response speed, number of errors, and trials to criteria. Furthermore, upper limits of delay for observable learning to take place have been determined for rats (twenty seconds) and pigeons (sixty seconds).

Studies have shown no definite trend toward either immediate KR or delayed KR as being best for human subjects. As of late, more material is appearing in the literature, which indicates experimental psychologists feel they can find an answer to this puzzling question: "When should the learner be reinforced?"
CHAPTER III

METHODS AND PROCEDURES

This investigation proposed to determine if three matched groups of seventh grade students, who experienced different levels of reinforcement, differed in learning after taking a teacher-constructed test. Included in this chapter are descriptions of the population and sample, procedures followed in this study, and method of analysis of data.

I. POPULATION AND SAMPLE

The sixty-three subjects in this study were drawn from two general science classes of seventh grade students in Tahoma Junior High School, Maple Valley, Washington. This school system is located in a semi-rural area within close commuting distance of two urban industrial areas which are located at Renton and Auburn. The population was composed primarily of children whose parents were directly connected with these industries.

II. PROCEDURES OF THE STUDY

Matching Procedures

All seventh grade general science students taught by the investigator were administered the Iowa Test of Basic
Skills (ITBS). This standardized achievement test has a composite reliability of from .97 to .98 for grade equivalent scores (13:16).

Following administration of the ITBS, each student's grade point average for the previous year and first semester of the current year was determined to the nearest whole point on a thirteen point scale. In addition, each subject's age was determined to the nearest whole month.

After determining individual characteristics from the above data, the subjects were then separated by sex and matched in triads using grade equivalent on the ITBS, grade point average, and age. Subjects in each triad were then assigned by the use of a random number table into one of the following three groups:

1. Immediate Reinforcement Group--An experimental group which received knowledge of results immediately after selecting each answer assumed correct.
2. Delayed Reinforcement Group--An experimental group which received delayed knowledge of results twenty-four hours after testing.
3. Nonreinforcement Group--The control group which received no knowledge of results during the investigation.
Preparation of Subjects for the Test

All subjects were taught a physical geology science unit spanning thirteen class periods of fifty minutes each. This unit was selected as the school district curriculum guide indicated that the students had minimal previous knowledge of this area.

Description of the Test

The unit test contained fifteen objective, multiple-choice questions of a factual recall nature and fifteen objective, multiple-choice questions requiring inductive reasoning. All questions contained four choices. (See Appendix A.)

An item analysis utilizing the results obtained from testing students not connected with the study was conducted prior to the experiment. The objectives of the item analysis were to ascertain question difficulty and to discover any errors in construction of the questions. A third purpose of the item analysis was to meet the definition of a teacher-constructed test as described in the first chapter of this paper.

In addition to questions, the tests included the correct answers located to the immediate right of the blank provided for answering each question. The answer was covered by a piece of self-duplicating paper which extended over the answer blank. Glued beneath the self-duplicating paper in
the blank was a second piece of self-duplicating paper. This was necessary to produce an identical mark when the top piece of paper was marked. This also prevented answers from being changed.

For reinforcement, the subjects were instructed to pull off the top piece of self-duplicating paper after answering the question; this exposed the correct answer to the subject.

**Testing Orientation**

After reading the instructions to the subjects, the investigator presented two sample questions and directed the delayed and nonreinforcement groups to study the question for thirty seconds, print their answers to the question on the blank during a ten second interval, and to cover all questions and rest for twenty seconds.

The immediate reinforcement group tested in a separate room was given thirty seconds to study each question, ten seconds to answer each question, ten seconds to lift the tab and expose their answer for reinforcement, and to cover all questions and answers for ten seconds.

All questions not being considered were to be covered at all times. This was accomplished by providing the subjects with two sheets of opaque paper—one to cover the questions above and one to cover the questions below the one being considered at any given time.
Session 1

During the first session the subjects viewed each factual question for thirty seconds. They were then directed to answer their questions by placing A, B, C, or D on the blank to the left of each question during a ten second interval. During the ten seconds following the answer interval, the immediate KR group viewed the question and answer for ten seconds while the delayed and nonreinforcement groups rested for ten seconds. All groups rested during the next ten second interval. (See Appendix B.)

The reasoning questions were presented for sixty seconds to all groups and subjects were provided with ten seconds to answer each question. The immediate KR group then had ten seconds to view the correct answer followed by a ten second rest. The delayed and nonreinforcement groups rested during the interval the immediate group was reinforced plus another ten seconds. (See Appendix B.)

Session 2

The second session, twenty-four hours after Session 1, involved only the delayed reinforcement group. As in the first session, the two opaque papers were used to cover all questions not being considered. Subjects were instructed to uncover the answer by lifting the tab and to view the correct answer for ten seconds as the immediate group did in Session 1. They were then instructed to cover the
question for ten seconds before instructions were given to uncover the next question. This procedure was followed for all factual and reasoning questions until reinforcement was completed.

Session 3

One week following Session 2, all groups were retested with the same questions in rearranged order. In addition, the choices were rearranged. Both factual and reasoning questions were presented with the same time intervals as in Session 1, but the reinforcement interval and corresponding ten second rest period for the delayed and nonreinforcement groups were omitted. (See Appendix B.)

III. ANALYSIS OF DATA

The data collected was derived from the individual difference scores from Session 1 and Session 3 for the three groups. The differences were compared between the groups for the factual and reasoning subtests as well as the total test.

The instrument used for analysis of data was a t test of the differences between means. The level of confidence selected was .05.
CHAPTER IV

STATISTICAL RESULTS OF THE TEST

The dependent variable measured and analyzed was the individual difference score between the test for placement (Session 1) and the test for retention after reinforcement (Session 3). An individual's difference score was determined by subtracting his score for placement from his score for retention.

The t test of the differences between two means (see 7:348) was used to compare the delayed and nonreinforcement groups. The delayed group was favored significantly ($p < .05$) on both subtests and on the total test. These results necessitated rejection of the hypothesis that there will be no difference in learning between the delayed and nonreinforcement groups.

Similarly, the $t$ test used to compare the nonreinforcement group and the immediate reinforcement group indicated that there was a significant difference ($p < .05$) between the groups on the total test. The results favored the immediate reinforcement group. Conversely, no difference was found in comparing the subtest means of the two groups. Therefore, the second hypothesis indicating that there will be no difference between the immediate and nonreinforcement groups
was rejected on the total test but could not be rejected for the subtest comparisons.

In comparing the delayed and immediate reinforcement groups, the t-test of the differences between means showed no significant differences on either the total test or the subtests. The third hypothesis which stated that there would be no difference between the delayed and immediate reinforcement groups cannot be rejected since the difference in all cases was not statistically significant.

Tables I, II, and III summarize the statistical results of this investigation.
<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>(S.D.)²</th>
<th>t</th>
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<tr>
<td>Delayed</td>
<td>17</td>
<td>1.47</td>
<td>3.19</td>
<td>2.14*</td>
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<tr>
<td>Control</td>
<td>17</td>
<td>-0.35</td>
<td>8.22</td>
<td></td>
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<tr>
<td>Immediate</td>
<td>17</td>
<td>1.24</td>
<td>4.46</td>
<td>1.78</td>
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<tr>
<td>Control</td>
<td>17</td>
<td>-0.35</td>
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<tr>
<td>Immediate</td>
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<td>1.24</td>
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<td>0.33</td>
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<tr>
<td>Delayed</td>
<td>17</td>
<td>1.47</td>
<td>3.19</td>
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</table>

*Significant at the 5% level

\[0.05t = 2.04\]

\[\text{df} = 30\]
TABLE II

REASONING SUBTEST: GROUP COMPARISONS OF INDIVIDUAL SUBJECTS

DIFFERENCE SCORES (SESSION 3 MINUS SESSION 1)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>(S.D.)^2</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay</td>
<td>17</td>
<td>+2.12</td>
<td>7.77</td>
<td>2.18*</td>
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<tr>
<td>Control</td>
<td>17</td>
<td>+0.18</td>
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<tr>
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<td>17</td>
<td>+1.00</td>
<td>5.53</td>
<td>1.01</td>
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<tr>
<td>Control</td>
<td>17</td>
<td>+0.18</td>
<td>5.06</td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>17</td>
<td>+1.00</td>
<td>5.53</td>
<td>1.27</td>
</tr>
<tr>
<td>Delay</td>
<td>17</td>
<td>+2.12</td>
<td>7.77</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the 5% level

\[
0.05t = 2.04 \\
\text{df} = 30
\]
TABLE III
TOTAL TEST: GROUP COMPARISONS OF INDIVIDUAL SUBJECTS' DIFFERENCE SCORES (SESSION 3 MINUS SESSION 1)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>(S.D.)²</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed Control</td>
<td>17</td>
<td>+3.59</td>
<td>2.36</td>
<td>3.80*</td>
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<tr>
<td>Immediate Control</td>
<td>17</td>
<td>-0.18</td>
<td>13.56</td>
<td>2.11*</td>
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<tr>
<td>Immediate Delayed</td>
<td>17</td>
<td>+2.24</td>
<td>7.23</td>
<td>1.75</td>
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<td></td>
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</table>

*Significant at the 5% level

\[0.05t = 2.04\]
\[df = 30\]
CHAPTER V

DISCUSSION AND RECOMMENDATIONS

I. DISCUSSION

Delayed and Nonreinforcement Group Comparisons

Statistical results of the t test comparisons between the delayed and nonreinforcement group means showed that the delayed reinforcement group was statistically significant in learning over the nonreinforcement group. This result was expected as the nonreinforcement group was never exposed to the correct answers or, for that matter, to any answers. A second possible reason for the poorer performance of the nonreinforcement group might be attributed to the experiment being generally unrewarding to the subjects. That is, the only difference that they could observe in the test was the test paper itself. The investigator must discount this possibility because the subjects were extremely interested in participating in the experiment. Also, the unusual test paper plus the requirements for covering all questions that were not being considered, appeared to maintain their interest.

Immediate and Nonreinforcement Group Comparisons

The t test of the immediate and nonreinforcement group means showed that over the total test the immediate
group was significantly superior to the nonreinforcement group. The immediate group was not significantly superior to the nonreinforcement group on the subtests. The significance found on the total test was expected because of the lack of exposure to the correct answers for the nonreinforcement group.

**Immediate and Delayed Reinforcement Group Comparisons**

The t test results showed that there was no significant difference between the immediate and delayed reinforcement groups on the subtests or on the total test. It must be pointed out that in all cases the delayed group was superior to the immediate group. The delay could have facilitated learning since once the subjects attempted the question, they did not stop considering them.

It might be noted that the delayed group was exposed to the test a day closer to the test for retention than were the immediate and nonreinforcement groups. However, Sturges and Crawford used a similar design with the test for retention six days after delayed reinforcement, and stated that according to all published material on forgetting and retention, forgetting reaches a limiting position before this and shows no appreciable daily loss by the end of such a period (50:19).
II. RECOMMENDATIONS

Utilization of public school pupils is necessary for educational generalizations. Unfortunately, in the public school classrooms groups are generally quite small for statistical samples. In addition, absences seriously affected this study's sample size. With the matched triads used in this study, any missing subject necessarily removed two other subjects from the study. Twelve of the sixty-three subjects had to be removed for this reason.

Two problems must be noted in relation to the self-duplicating paper. Answers printed on the first pages of the test were printed on the following pages if the blanks were beneath one another. The investigator does not feel this affected his determination of the intent of the subjects, but careful scrutiny was required of some answers. The gluing of tabs was much more difficult and trying than was expected. If one is interested in other reinforcement instruments and has an adequate budget, lantern slides or 35mm slides could be used with perhaps greater ease and efficiency. If either alternate is selected, an adequate number of monitors will probably be necessary to prevent cheating with the immediate group.

It is recommended that careful consideration be given to reinforcement in the classroom as related to testing and
to answering questions by the teacher. It does not appear that a definite reinforcement schedule is the "best" way for either factual or reasoning questions, but it is implied that, for questions of a reasoning nature, learning might be facilitated if reinforcement is delayed.

Further research appears necessary to resolve the questions of delayed versus immediate knowledge of results in human learning. As indicated in the second chapter of this paper, conflicting information on human learning is quite evident and many more studies must be performed before sound generalizations can be made.

Whatever is decided from future experiments, a teacher cannot afford to present either type of reinforcement to the exclusion of the other. In the classroom, assorted reinforcement can positively affect pupil interest. A teacher who will never answer a question immediately could obstruct the very thing he seeks—the asking of questions—whereas, answering all questions immediately can tend to set the teacher apart from his students.

In general, there is admittedly and recognizably a need for more research to be done on the timing of reinforcement, as present findings can provide no definitive answers for the classroom teacher. One should not make the frequent error of generalizing or overly depending on animal studies to guide classroom procedures. These studies can be of
value only if used comparatively and as a point of departure. The answers that lie ahead must be determined from experiments under less than ideal circumstances in the public school classroom, where teaching and learning with students take place.
BIBLIOGRAPHY


APPENDIX A

SAMPLE FACTUAL AND REASONING TEST QUESTIONS
SAMPLE FACTUAL QUESTIONS

1. _____ C  
The remains or imprints of prehistoric life are called: (A) relics (B) sediments (C) fossils (D) antiques.

2. _____ D  
The underground level of water in an area is called the: (A) aquifer (B) zone of aeration (C) zone of saturation (D) water table.

3. _____ D  
All erosion on the earth can be traced to: (A) the wind (B) water (C) glaciers (D) gravity.

4. _____ B  
Petrologists study: (A) seismic waves (B) rocks (C) structural geology (D) wind erosion.
1. **C**  
Rocks near glaciers are frequently split apart rather than ground up. A possible reason for this is: (A) meteorites have struck them (B) running water has split them (C) alternate freezing and thawing split them (D) that winds caused this.

2. **D**  
In this area, we find large rocks that appear to have originated in Canada. These rocks were probably carried here by: (A) floods (B) winds (C) the earth's rotation (D) glaciers.

3. **A**  
The upper center of a stream moves faster than the rest of the stream. It could be that this area: (A) has less frictional contact than any other part of the stream (B) the wind helps its movement (C) has material floating in it (D) is at the highest point of the stream.

4. **D**  
After Krakatoa exploded in 1883, for four months the sky in a band around the world at that latitude was colored grey-brown. This probably lasted this long because: (A) no rain pulled the particles down (B) the dust particles were lighter than air (C) condensed water vapor held them up there (D) air currents kept the particles up in the air.
APPENDIX B

REINFORCEMENT SCHEDULE FOR FACTUAL AND REASONING SUBTESTS
### Table IV

**FACTUAL QUESTION SCHEDULE WITH TIME IN SECONDS**

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TABLE V

INDUCTIVE QUESTION SCHEDULE WITH TIME IN SECONDS

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