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The significance of an additive time pattern in learning a motor skill

Arnold, Mary Elizabeth

Boston University

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THE SIGNIFICANCE OF AN ADDITIVE TIME PATTERN IN LEARNING A MOTOR SKILL

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Thesis

THE SIGNIFICANCE OF AN ADDITIVE TIME PATTERN
IN LEARNING A MOTOR SKILL

Submitted by
Mary Elizabeth Arnold
(E. S., Boston University, Sargent College, 1945)

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

1949
Gift of
Mary E. Arnold
School of Education
August, 1949
31280
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Approval Page

Thesis Approved:

First Reader: Dr. Arthur G. Miller, Assistant Professor of Education

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Introduction

In the past, the outcomes of physical education were not susceptible to evaluation by tests and measurements. Consequently, little objective data was available in the field. In the modern scientific world, however, objective methods of appraisal applicable to physical education have been developed. As a result of these developments, the experimental method is being employed by many investigators in analyzing the major problem in physical education.

In a series of discussions with Dr. Arthur G. Miller, the author became aware of the additive time pattern which was set forth in his experiment. As a result of this contact, a desire was aroused to further study this additive time pattern. In order to do this, students at Saint Joseph's College, Emmitsburg, Maryland were selected to participate in this study.

Statement of the problem

The title given to this study is "The Significance of an Additive Time Pattern in Learning a Motor Skill." By "Additive Time Pattern" is meant an increase in the number of days in intervals between tests as the study progressed.
After the first and second period for testing were determined, each new interval in the time pattern was obtained by securing the sum of the two preceding intervals.

Motor skill as employed herein refers to the acquisition of skill in the performance of shooting set shots in billiards.

**Purpose of the study**

The purpose of the study was to determine the significance of one particular time pattern in learning a motor skill through the medium of billiards. The time pattern used was the additive time pattern.
CHAPTER II

REVIEW OF THE LITERATURE

Not too many experiments have been conducted in regard to the work that has been carried out in this experiment. Most of the authors wrote simply on massed and spaced practices relative to mental skills and devoted little time to massed and spaced practice in motor skills. It is evident, therefore, that modern educators will find in the study of motor skills a broad field of investigation.

Most of the authors who have delved into this subject have agreed in their findings on the following points, namely:

1. That distributed practice is more effective for securing gains than massed practice.
2. Long practice periods should be avoided.
3. There is a limit below which it is not profitable to reduce the length of time spent at one practice.
4. Fatigue at the end of long periods makes it advisable not to have lengthy periods.
5. Youngsters are more easily fatigued than older ones.
6. In deciding how long one should practice at one time in order to secure the most efficient use
of time, one should consider the nature of the task, the age of the learner, the difficulty of the task, and the stage of learning.\(^1\)

Intervals that are too long may be unfavorable. It is best not to spread out the time so long that the learner will lose interest in the work or suffer the loss of previous gains. Short periods of practice stimulate primary growth which continues through the interpractice interval.

Kingsley\(^2\), in his book has said, "distributed practice is usually more effective for the time spent than massed practice." The reasons that Kingsley has given for his statement is this: "The best distribution varies for different tasks. For younger children, for difficult tasks, and in the early stages of learning, short periods of practice are desirable."\(^3\)

Skill is acquired through formation of connections between sensory stimuli and motor responses. In other words, the adaption of a movement to a stimulus.

In any motor skill, whether it be drawing, typewriting, writing, or in gymnastic activities, the goal sought is

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2. Ibid., p. 247.

3. Ibid., p. 248.
physical or muscular skill. The chief function in learning is not primarily to be able to make correctly the separate movements, but rather in linking them together so that they follow readily in proper order. In every sensori-motor learning situation, there is a definite technique which is best for the learner to use. This means that the achieving of this technique must be taught by imitation and verbal direction. Much better results will be achieved in sensori-motor learning if the pupil centers his attention on the details to be mastered; if he concentrates on points giving him difficulties; if he uses his will to secure a faithful application of effort during periods of practice.

Book\(^1\) has said that "for a man to change his mode of response in any respect, there must be a stimulus which makes an impression upon its receptor organs."

Book\(^2\) has further mentioned that the experiments on spaced practice in learning suggest the influence of some such perseveration tendency and the theory that linkages between associations and between a particular stimulus and its appropriate response tend to be strengthened for a time after the stimulus is withdrawn. This is known as "Jost's Law." If two associations are of equal strength but of

---

2. Ibid., p. 74.
different age, a new repetition has a greater value for the older one. This hypothesis is an explanation of the effectiveness of positive distribution. Such cumulative after-effects of stimulation have important significance for the fixing of any responses that are to be acquired. Sufficient stimulation must occur to secure such cumulative results, and the practice should be so spread that the full after-effects may be obtained.

Boring, Langfeld, and Weld in their book have brought out the point that we measure learning and retention in terms of how much change in performance has taken place in a given unit of time or effort. They gave the name learning to an incremental change which resulted from practice and its attendant conditions.

In regard to massing and spacing, these authors gave the theory that trials taken in immediate succession are massed, while those having an interval between are said to be a distribution of practice.

These authors have specifically stated that: "The conclusion is well established that over a wide range of conditions, some form of positive distribution is a more favorable condition of learning than is massed practice."

3. Ibid., p. 322.
Brennan has stated that "it has been experimentally established that spaced practice is much more effectual in securing good results than any other kind of temporal distribution. The optimum length of the rest period is roughly proportioned to the time it takes to learn a task."

Ebbinghaus, in his experiments has proven the value of distributed learning over concentrated learning. Jost, in his experiments, found a saving of about 15 per cent in favor of distributed learning. Lyon found distributed learning to give better retention than learning confined to a single sitting. Robinson found distributed learning superior to concentrated learning with respect to the amount retained and of the accuracy to recall. Gates has shown that distributed learning is much better than massed learning. In his experiments, he has shown that a person can retain the content of a lesson when he has distributed his learning, better than a person who has "crammed" his information only long enough to pass an examination.2

Boring,3 along with his associates, has expressed the idea that when a period of time separates each trial in learning, the method is called distributed practice. When

trials are given without a break, the method is called massed practice. They have shown that in almost every case, some sort of distributed practice is more effective than massed.

The length of the time interval between trials is a critical factor in the relative effectiveness of massed and distributed practice. If the time is very short or of zero duration, learning is likely to suffer because of reduced motivation, interference and fatigue. If, on the other hand, the interval is too long, considerable forgetting will occur between trials, and hence the efficiency of learning will be reduced.

For many activities, a variation in the length of the interval between trials as learning progresses is beneficial. For certain activities, massing in the early stages of learning with distributed practice later, is best. For others, the pattern of distributed practice at first, followed by progressively shorter intervals between trials is optional.

A number of studies have indicated that the longer and more difficult the task, the more effective is distributed practice. Some of the factors that might have led to this explanation of the superiority of distributed practice over massed practice are fatigue and motivation. The latter is most important in the effectiveness of spaced practice.
There are two other men that have done a great deal of work in this field and their conclusions should be noted. The names of these two men which we will consider now are Hollingworth and Poffenberger. In their work they have stated, "moderate distribution of time always gives more economical results than spending the same amount of time in one continuous study period. Activity causes an increase in the nutrition of the part used, and these nutritive changes, whether they occur in the nerve or in the muscle mechanism, would be most furthered by a distribution of time - that is working time. Too great a concentration of time is not economical."

As we read the works that have been done in this field, we see that most of the authors are in accord with the idea that distribution of time or practice is most beneficial to the learner and greater results will occur.

Yerkes has shown that "a subject is better retained when the learning extends over a considerable period of time. Brief intervals of practice are more valuable than long continued practice."


Witherington\(^1\) and later on Peterson\(^2\) and his associates, have shown that distributed practice in learning is more effective if the work periods are spaced and not too concentrated. Also, that massed practice is mainly objectional because of fatigue or boredom.

Distribution of practice generally makes for economy. Under distribution of practice, a skill is acquired with less effort than if the practice were massed. There may be variations in the duration of the interval of the distributed practice.

Lorge\(^3\), in the introduction of his book, has cited the work of Ruch who in 1928 gave his summary of the experimental literature on distribution and massing of practice. He (Ruch), stated the following as of major importance: first, the general characteristics of the distribution of practice (number and length of periods, intervals between periods, degrees of learning being considered etc.) second, the type of material being learned; third, the age of the subjects; fourth, the aim of the learning; fifth, order of repetitions within a practice period; sixth, manner of studying; seventh, the stage of learning.

The work of Lorge was to ascertain what differences in efficiency, if any, result at trials subsequent to each regular interpolation of a constant time interval in a practice series.

Lorge\textsuperscript{1} also stated that any study in distribution must consider at least the following five variables:

1. Duration of the interpolated interval.
2. Frequency of the interpolations.
3. Unit of practice.
4. Number of units of practice.
5. Stage of learning at which interpolations are introduced.

Snoddy\textsuperscript{2} developed evidence of two opposed processes in mental growth, primary growth (that growth in learning which appears early, is stable, is a positive function of repetition and interpolated time) and secondary growth (that growth in learning which appears later, is highly unstable, is enhanced by withdrawal of time and lost through the effect of long intervals interpolated in the practice.)

From Snoddy's results and conclusions which were included in Lorge's book, it was seen that Snoddy allowed groups to trace a maze under conditions of distributed and of massed practice. The maze was the stabilimeter, an adaption made by Snoddy of the conventional mirror-drawing experiment.\textsuperscript{3}

\begin{enumerate}
\item Lorge, loc. cit., p. 3.
\item Lorge, loc. cit. p. 4.
\end{enumerate}
The rate of improvement is a function of the length of the time interval only during the early part of the practice when the coordination pattern is being built. Beyond this early adaption stage, the improvement is a function of the number of repetitions.

Learning under the conditions of distribution is more efficient than under the conditions of massing. It is believed that the time interval will promote an efficiency beyond that attained under massing, at least until the skill is acquired. The process of learning may be more satisfying and receive better attention when rest periods intervene.

Miller\(^1\), in his work on billiards, found that the additive time interval pattern produced the best results. Progressively lengthening the time interval between the practice periods (the additive pattern) proves beneficial in learning a new motor skill. His experiment was concerned with primary growth.

McGeoch\(^2\) in his book has pointed out the generalization that some form of positive distribution yields faster learning than does massed practice. This stands as one of our most general conclusions.


The optimal length of rest interval varies with a number of conditions, but the differences between rates of learning with different rest intervals are seldom as large as the differences between massed practice and any of the forms of distribution. It is evident that there must be limits to the length of the rest interval which can be favorable to learning, if for no other reason than after very long intervals of the order of weeks or months, forgetting will be large, and the time required for relearning will be great.

Over a wide range of conditions, distribution of practice yields faster learning, greater retention after an interval following the close of practice, or both, than does massed practice.

The writings of Snoddy imply a stimulus-maturation hypothesis which has been stated by Dore' and Hilgard:

At any given age-maturation level, the optimum rate of stimulation to secure improvement in a given function depends upon the normal rate of stimulation-induced maturation in that function."


It is a reasonable hypothesis that learning is more rapid under distributed practice than under massed because the rest intervals give opportunity for differential forgetting. Massed practice either strengthens conflicting associations or permits them to remain longer at a relatively higher level of strength and therefore requires more practice to bring the correct responses to dominance.

Troy,¹ in his experiments with billiards, found his greater gains were made between Monday and Wednesday than between Wednesday and Monday. He concluded that practices should be conducted more frequently than twice a week for maximum performance.

The results of Dore' and Hilgard,² obtained on a pursuit-meter, agree with those of Cummins that increasing lengths of rest intervals yield more rapid learning than do decreasing lengths, when the total number of trials and the total time covered by the experiment are constant.

Cummins³ found that a decrease in study period concomitant with an increase in length of rest interval slightly


superior to a schedule in which the two are kept constant, thus corroborating the conclusion that short intervals are more effective early in practice and long ones later.

Perkins\(^1\) implied that length of study periods is a more potent variable than is the length of the rest interval.

Travis\(^2\) whose results on learning a form of manual pursuit, implied that a longer practice period required a longer rest interval for the most rapid learning.

Lashley\(^3\) suggested that distributed practice should be especially effective during the exploratory stage, because massing of trials leads to a diminution in the variability of responses which is necessary for solution.

Cook\(^4\) predicted that massed practice should be more effective in the early trials.

The continuous work demanded by massed practice may be accompanied by declining motivation, which in turn operates to produce a decreased rate of learning. The rest intervals

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of positive distribution may, on the other hand, permit the subject to return to the practice with a higher motivation and a resultant greater efficiency.

The experiments on distribution of practice have found that the introduction of time intervals between practice periods of varying lengths yielded more rapid learning, under a wide range of conditions, than did continuous practice.

Longley\(^1\), in his experiment with billiards, found that learning took place and that fatigue was kept at a minimum while interest was kept at a maximum. Longley substantiated Miller's conclusion that massed practice followed by spaced practice (in some form) is better than massing alone or spacing alone. His group met three days in succession followed by weekly practice periods.

Thus, from reading the works that the experimenters have done, the conclusion has been reached that distributed practice yields better results than does massed practice for the more difficult and complex skills. However, there is a need for further study on specific time patterns and their relation to the learning process.

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CHAPTER III

PROCEDURE

Procedure

The research was done on a primary level of learning. Primary growth is that growth in learning which appears early, is stable, and is a positive function of repetition and interpolated time. The group started with twenty-eight college girls that had had no previous experience with either pool or billiards. At the end of the experiment, there were twenty girls left. Eight girls dropped out during the course of the nine practices.

The apparatus included a billiard table, a cue stick and three billiard balls. The five set shots that were used are shown on page 22.

The additive time pattern represented nine practice sessions that were spaced in the following chronological order of days: 1-2-3-5-8-13-21-34-55. These additive time patterns were reached in the following manner: adding the first two numbers or days to make the third number or day (1st day plus 2nd day equals 3rd day); the second and third numbers or days to make the fourth number or day (2nd plus 3rd equals 5th); the third and fourth numbers or days to

make the fifth number or day (3rd plus 5th equals 8th); etc. up to and including the fifty-fifth day which was the ninth practice session. The first day's practice was begun on a Thursday (1st day) followed by practice period on Friday (2nd day), Saturday (3rd day), Monday (5th day), Thursday (6th day), etc. Out of the nine practice periods, two fell on Thursday, one on Friday, one on Saturday, one on Monday, three on Tuesday, and one on Wednesday.

The actual dates of the practice periods were as follows: Section I - October 7-8-9-11-14-19-27, November 9-30. The time for Section II - October 21-22-23-25-28, November 2-10-23, December 14. Each section had nine practice periods in accordance with this time pattern. The first practice period was devoted to a standardized explanation of the fundamentals of the game. The cooperation of the girls was assured at this time and an explanation of the research problem given to assure their attendance. During the first practice, the instructor gave corrections to the students but after that first practice, no help was given to the students. The scores of the first practice were kept but these scores were not used in the final statistics.

During each practice session, there were two subjects and the instructor in the practice room at one time. One student recorded while the other student did her shots and then the act was reversed. The instructor set the balls on
their proper spots on the table. Each subject had fifty shots per practice period. Hence, each shot was tried five times from the right side and five times from the left side for a total of ten times.\(^1\)

All of the subjects agreed to play no pool or billiards for the length of the experiment.

**Explanation**

As soon as both girls were in the room, the instructor gave the following explanation about the game. There were three balls: one ball was called the cue ball, the red ball was called the first target ball, and the other ball was called the second target ball. Here the instructor explained what was meant by a billiard. With this she used her hands. Explaining that it was all a matter of angles and that to constitute a billiard, one must hit the cue ball which must in turn hit the red ball and then the cue ball must hit the second target ball. When this had been accomplished, a billiard had been made. If one wanted to hit a ball on the right, one would hit the target ball on the right. To hit a ball on the left, one would have to hit the target ball on the left. One must always hit the red ball with the cue ball and then the other ball.

The following explanation was given for the handling of a cue stick if the subject was right handed. The left

\(^1\) A sample score sheet is included in the Appendix.
hand was called the bridge. Placing the left hand three or four inches back of the cue ball, one held the cue stick lightly with the thumb and first two or three fingers. Then one rested the cue stick on the bridge hand over the thumb and under the fore finger. The work of the fore finger was to keep the cue stick from slipping. The ball was struck in the center by the cue stick and not on the side. The right shoulder was kept in and came down straight. The motion was from the elbow. The elbow was like a piston on a locomotor. The right arm was kept close to the body. The feet were about a foot apart and at a forty-five degree angle.

Throughout the entire experiment, the instructor never hit the ball while the students were in the room. After a girl had taken five shots, she would chalk her cue so that it would not slip off the ball. One girl took five shots from the one side and then the other girl took the same five shots. As one girl was shooting, the other girl did the recording. The instructor set up the target balls for the shots each time and the person doing the shooting set up the cue ball in accordance with instructions. Throughout the experiment, the girls were assigned to report at specific times and it was made clear to them that if they missed one practice session all their work would have to be discarded. The importance of this point was stressed at the first meeting. The instructor gave as much help as possible the first
lesson, but after that the girls were on their own and the instructor did not give help or offer any suggestions. The billiard table was of standard size.

At the start of the experiment, the instructor placed dots on the table for the exact place for the balls to be placed. In this way the balls were put in the proper place every time and there was no chance for error.
Chart I

Set Shots 1, 2, 3, 4, 5 on the Right and Left Sides of the Table Respectively.
CHAPTER IV
PRESENTATION AND ANALYSIS OF THE DATA

When the difference (D) in the means (M) is two and one half times the standard error (SE), the difference will be judged significant. A critical ratio (CR) of 2.5 will be considered indicative of a significant difference since there are 99.4 chances out of 100 that the mean gains for one group are greater than for another group.

The means, standard deviations, and ranges are shown in Table VI in the Appendix.

The mean scores for the nine practice periods are shown in Diagram I, page 24.

Table I on page 23 shows the differences in the means of the nine practice periods, along with the standard error of the difference and the critical ratio.

Table I
DIFFERENCES IN MEANS OF THE NINE PRACTICE PERIODS

<table>
<thead>
<tr>
<th>Practices</th>
<th>Mdiff</th>
<th>SEdiff</th>
<th>D.F.</th>
<th>CR</th>
</tr>
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<tr>
<td>P2-P3</td>
<td>.8</td>
<td>2.5</td>
<td>19</td>
<td>.67</td>
</tr>
<tr>
<td>P3-P4</td>
<td>2.3</td>
<td>2.3</td>
<td>19</td>
<td>2.2</td>
</tr>
<tr>
<td>P4-P5</td>
<td>-.1</td>
<td>2.1</td>
<td>19</td>
<td>.10</td>
</tr>
<tr>
<td>P5-P6</td>
<td>-1.5</td>
<td>2.2</td>
<td>19</td>
<td>1.2</td>
</tr>
<tr>
<td>P6-P7</td>
<td>1.1</td>
<td>2.1</td>
<td>19</td>
<td>1.1</td>
</tr>
<tr>
<td>P7-P8</td>
<td>-1.0</td>
<td>2.2</td>
<td>19</td>
<td>1.0</td>
</tr>
<tr>
<td>P8-P9</td>
<td>2.2</td>
<td>1.9</td>
<td>19</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Although the scores of the critical ratio for the individual practices were judged insignificant, those practices that more nearly approached statistical significance were practice three-practice four with a critical ratio of 2.2 and practice eight-practice nine with a critical ratio of 2.4.
Diagram I

Mean Scores of the Additive Group for the Nine Practice Periods Using All Set Shots.

<table>
<thead>
<tr>
<th>Practice Period</th>
<th>Mean Scores for the Nine Practice Periods Using All Set Shots</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.130</td>
</tr>
<tr>
<td>2</td>
<td>3.138</td>
</tr>
<tr>
<td>3</td>
<td>4.161</td>
</tr>
<tr>
<td>4</td>
<td>5.160</td>
</tr>
<tr>
<td>5</td>
<td>6.145</td>
</tr>
<tr>
<td>6</td>
<td>7.152</td>
</tr>
<tr>
<td>7</td>
<td>8.146</td>
</tr>
<tr>
<td>8</td>
<td>9.168</td>
</tr>
</tbody>
</table>

Mean Scores
Table II

THE CRITICAL RATIO OF THE DIFFERENCES BETWEEN THE SECOND PRACTICE PERIOD AND THE NINTH PRACTICE PERIOD

<table>
<thead>
<tr>
<th>Practice No.</th>
<th>Mean</th>
<th>SE_m</th>
<th>D_mmg</th>
<th>SE_d</th>
<th>C.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>20</td>
<td>15.0</td>
<td>1.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>16.8</td>
<td>0.74</td>
<td>3.8</td>
<td>1.4</td>
</tr>
</tbody>
</table>

The critical ratio of the difference between the means of the second practice and the ninth practice period was 2.7. There were 99.6 chances out of 100 that the true difference was greater than zero, that is, there were 99.6 chances out of 100 that the mean of the last practice was greater than the mean of the second practice period for the additive group. This showed a statistical significance.

The different intervals made no significant difference in this experiment. The scores fluctuated from test to test, but these fluctuations revealed no superior gain between any specific practice. However, there was a gain in the overall picture.

Diagram II shows a comparison of Longley's and Arnold's set shots 2-5 inclusive. Set shot 1 could not be used as it was different. It will be noted that there was a greater gain in the pattern used by Longley than that used by Arnold. This was different than when the results obtained by Miller's additive pattern were compared with Longley's.
Longley's Mean Scores for Set Shots: 2, 3, 4, 5
Arnold's Mean Scores for Set Shots: 2, 3, 4, 5

<table>
<thead>
<tr>
<th>Practice Periods</th>
<th>Longley's Scores</th>
<th>Arnold's Scores</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>14.4</td>
<td>12.6</td>
</tr>
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<td>3</td>
<td>14.7</td>
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<td>6</td>
<td>18.8</td>
<td>13.8</td>
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<tr>
<td>7</td>
<td>20.5</td>
<td>15.1</td>
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<tr>
<td>8</td>
<td>20.0</td>
<td>13.8</td>
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<tr>
<td>9</td>
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<td>14.2</td>
</tr>
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</table>
Table III
DIFFERENCE IN MEAN OF THE SECOND PRACTICE PERIOD AND THE NINTH PRACTICE PERIOD FOR ARNOLD'S ADDITIVE GROUP FOR SHOTS 2-5

<table>
<thead>
<tr>
<th>Practice No.</th>
<th>Mean</th>
<th>SEm</th>
<th>Dm2mg9</th>
<th>SEd</th>
<th>C.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
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<td>12.6</td>
<td>1.2</td>
<td>3.6</td>
<td>2.2</td>
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<td>20</td>
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<td>1.9</td>
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Table IV
DIFFERENCE IN MEAN OF THE SECOND PRACTICE PERIOD AND THE NINTH PRACTICE PERIOD FOR LONGLEY'S MAPPED-EQUAL SPACED GROUP FOR SHOTS 2-5

<table>
<thead>
<tr>
<th>Practice No.</th>
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<th>Dm2mg9</th>
<th>SEd</th>
<th>C.R.</th>
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<tbody>
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Table V
DIFFERENCE IN MEAN GAINS OF SET SHOTS 2-5 FOR ARNOLD'S ADDITIVE GROUP AND LONGLEY'S MAPPED-EQUAL SPACED GROUP FOR THE SECOND AND NINTH PRACTICE PERIODS

<table>
<thead>
<tr>
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<th>Dm2mg9</th>
<th>SEd</th>
<th>C.R.</th>
</tr>
</thead>
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<td>Additive</td>
<td>20</td>
<td>3.6</td>
<td>2.2</td>
<td>1.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Longley's</td>
<td>Massed-equal</td>
<td>20</td>
<td>5.1</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The critical ratio of the difference between Arnold's Additive group and Longley's Massed-equal spaced group was 0.54. There were 70.7 chances out of 100 that the true difference was greater than zero, that is, there were 70.7 chances out of 100 that the mean gain for Longley's Massed-equal spaced group was greater than the mean gain for Arnold's Additive time group. This was not statistically significant.
CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

A study of an additive time pattern in learning a motor skill in relation to an interpolated time pattern was conducted in an experiment based upon billiards. This study was controlled at all times and interest maintained. Twenty women students of Saint Joseph's College, Emmitsburg, Maryland were used as subjects and completed the entire experiment.

Five set shots were used throughout the experiment. These five set shots consisted of ten tries, five on the right side of the table, and five on the left side of the table, making a total of ten tries per set shot with fifty shots per practice. The practice sessions were spaced out according to the additive time pattern. Fifty shots at each session for eight sessions made a grand total of four hundred shots per pupil; or a total of eight thousand (8000) shots for a final analysis.

All other factors were kept the same and these were maintained for the entire group during the experiment.

At the end of the experiment, all information was analyzed and treated statistically.

From the results of the experiment, it was seen that the students participating found the number one shot the
The reason for this result is the fact that the author in placing the dots on the table for the various shots, placed the dot for the red ball of shot number one on the center line rather than on the three-quarter line of the table which made the shot far more difficult than the one suggested by Miller. This could be one of the reasons why the scores of the experiment were so low.

In the degree of difficulty, the girls found the order of shots to be as follows: this is from the easiest to the hardest, 3, 2, 4, 5, 1.

If the number one shot had been placed in the correct position, the order of difficulty of the shots would have put the number one shot at the opposite end making it the easiest shot and permitting the girls to have higher scores. All of the other dots were placed in the proper positions at the start of the experiment and thus their scores were comparable to those in other experiments.

From the study of Longley, it was noted that the range of difficulty for the shots were as follows: 1, 2, 3, 4, 5; this from the easiest to the most difficult.

The additive score results of this experiment can not be compared to the additive score results of Miller because of the fact that the first shot used in this work was not the exact same one as used by Miller.

1. Longley, G. F., loc. cit.
The critical ratio of the difference between the means of the second practice and the ninth practice period was 2.7. There were 99.6 chances out of 100 that the true difference is greater than zero, that is, there are 99.6 chances out of 100 that the mean of the last practice is greater than the mean of the second practice period for the additive group. This was a significant difference as the established critical ratio of the experiment was 2.5.

The scores from the experiment showed that there was progress from the first lesson to the last session. The interest of the students was maintained throughout the entire work and at the end of the ninth session, the girls wanted to hold a tournament with other students in the school. The greatest gains were between the third and fourth practices and between the eighth and ninth practices.

Conclusions

Results indicate, that under the conditions of this experiment in regard to learning a new skill:

1. Fatigue was not a factor as distribution of practice provided sufficient rest periods.

2. Interest was maintained throughout the work.

3. Regularly increasing time-lapses between sessions revealed no appreciable results in achievement.

4. There was a greater gain in the pattern used by Longley than that used by Arnold. This was different than when the
results obtained by Miller's additive pattern were compared with Longley's. The mean gain for Longley's Massed-equal spaced group was greater than the mean gain for Arnold's Additive time group. This was not statistically significant.
BIBLIOGRAPHY
CHAPTER VI

BIBLIOGRAPHY


Cummins, R. A., "Improvement and the Distribution of Practice." Teachers College, Columbia, #97, 1919.


APPENDIX
Table VI

RAW SCORES, MEANS, RANGES AND STANDARD DEVIATIONS
FOR THE NINE PRACTICE SESSIONS

<table>
<thead>
<tr>
<th>Practice Periods</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
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<th>9</th>
<th>Totals</th>
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<tr>
<td>Names</td>
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Totals 260 273 323 320 291 312 292 336 2407

Means 13.0 13.8 16.1 16.0 14.5 15.6 14.6 16.8

S. D. 7.9 7.6 5.9 6.8 6.7 6.5 6.9 4.8

Ranges 6-21 6-21 8-26 8-29 8-26 6-26 7-21 11-23

Practice Periods 2 3 4 5 6 7 8 9

This table was for practice periods 2 through 9.
Table VII

RAW SCORES, MEANS, RANGES AND STANDARD DEVIATIONS FOR SET SHOT THREE FOR THE NINE PRACTICE SESSIONS

<table>
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Totals 103 109 138 134 117 124 130 147 1004

Means 5.1 5.4 6.9 6.7 5.8 6.2 6.5 7.3

S. D. 14.9 14.5 13.1 13.4 14.3 13.9 13.6 12.7

Ranges 2-8 1-9 2-10 3-10 2-10 1-9 3-9 4-10

Practice Periods 2 3 4 5 6 7 8 9
## Billiard Scores

**Score Sheet**

### Billiard Scores

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</tr>
</thead>
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<th>Left Side Scores</th>
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- **Total Right Side Score**
- **Total Left Side Score**
- **Total Right Side Score**
- **Total Score**

- **Successful Shot**
- **Unsuccessful Shot**

---

### Billiard Scores

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- **Total Right Side Score**
- **Total Left Side Score**
- **Total Right Side Score**
- **Total Score**

- **Successful Shot**
- **Unsuccessful Shot**