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A reliability check of two interpolated time patterns in motor learning

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A RELIABILITY CHECK OF TWO INTERPOLATED TIME PATTERNS IN MOTOR LEARNING

Submitted by

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CHAPTER I

INTRODUCTION AND PURPOSE

Introduction

During the author's period of undergraduate study, an interest in the field of time psychology was developed and stimulated by research carried on by Dr. Arthur Miller.[1] He had carried an experimentation trying to determine what effect intervals of interpolated time might have in learning a motor skill. His results proved very interesting but it was felt that a reliability check, pursued at a later date, might show more conclusively the significance of his results. In the Fall of 1948, during a series of conferences, it was decided to make a follow-up study on the findings which had been recorded in Miller's dissertation.

A Reliability Check of the Two Interpolated Time Patterns in Motor Learning consisted of making a recheck of five of the set shots used in the original experiment. The subjects used were girls who had participated in the first research.

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1. Miller, Arthur G. The Effect of Various Interpolated Time Patterns on Motor Learning. Unpublished Doctoral Dissertation, Boston University, 1948.

One of the conclusions reached by Miller was that by varying the time intervals between practices for different groups, certain statistically significant differences of achievement were noted. An additive pattern of massed practice followed by spaced had a more favorable effect upon learning than a daily pattern of continued massing. Yet it could not be said that the additive pattern of distributed learning yielded better retention than the daily pattern of massed learning.

Purpose

The purpose of this study is to make a reliability check on the results between two groups of subjects previously tested by Miller.[1] They are, the Additive Group (Group II) which produced the best effort in learning a motor skill, and the Daily Group (Group III) which proved to be one of the poorest of all time patterns tested. This check might be considered to be indicative of the degree of retention between massed-spaced learning and massed learning.

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1. See Page 1

CHAPTER II

REVIEW AND ANALYSIS OF THE LITERATURE

Review of the Literature

Snoddy[1] through experimentation with the stabilimeter (mirror writing) developed the theory of two opposed forces of mental growth, primary growth and secondary growth. Primary growth is that learning which appears early and is stable. Secondary growth is that learning which appears later and is highly unstable. Work carried on by Miller[2] has verified Snoddy's research concerning primary learning.

Miller[3] said that an interpolated time pattern of massed and spaced practice was better than either all massed practice or all spaced practice. Results of his research showed an additive pattern far superior to other patterns that were based on once a week practice, three times a week practice, and daily practice.

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1. Snoddy, G. S. Evidence for Two Opposed Processes in Mental Growth, Lancaster, Pa., 1935, Science Press, p. 103.

2. Miller, Arthur G. The Effect of Various Interpolated Time Patterns on Motor Learning. Doctor's Dissertation, Boston University, 1948.

3. Ibid., p. 51.

Longley's[1] study showed that massed followed by equal spaced practices gave results similar to Miller's additive pattern. He also verified the conclusion reached by Miller that one of the set shots might be considered a fair indicator of the total practice pattern.

Troy[2] carried on his research in this field on the secondary growth level. He concluded that practice on this level should perhaps be more than twice a week. As he used a different time pattern than Miller, and conducted his work on the secondary level, a true comparison cannot be shown.

The first quantitative work on retention of learning was done by Ebbinghaus.[3] In conducting research on memory and forgetting experiments, he found that the curve of retention showed a rapid drop during the first part of forgetting. Kingsley[4] went along with the general view that motor and verbal habits are retained equally well if they learned equally well.

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1. Longley, G. F. The Effect of Massed Followed by Evenly Spaced Practice on Learning a Motor Skill. Master's Thesis, Boston University, 1949.

2. Troy, John J. Jr. A Study of Peak Performances in Relation to Practice Periods. Master's Thesis, Boston University, 1948.

3. Woodworth, R. S. Experimental Psychology, New York, 1938, Holt Co., Ch.IX pp 211-216.

4. Kingsley, H. L. The Nature and Conditions of Learning, New York, 1946, Prentice-Hall, Inc., pp 499-500.

Blankenship[1] in his study on the memory span indicated that retention is reliant on the time of day, practice distraction, attitude, fatigue and other influences.

Bunch[2] conducted experimentation with rats running mazes and concluded that the superiority of the saving from retention over that from transfer is dependent to a great extent upon time.

Howland[3] found that when college students using lists of nonsense syllables were tested for retention of learning, those who had participated in distributed practice showed higher results than those who had participated in mass practice. The time interval for the distributed practice extended to a length of two days.

Cain and Willey[4] also found using nonsense syllables that recall scores were substantially higher for distributed

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1. Blankenship, Albert B. "Memory Span: A Review of the Literature", Psychological Bulletin, 1938, 35: 1-25.

2. Bunch, M. E. "A Comparison of Retention and Transfer of Training from Similar Material after Relatively Long Periods of Time", Journal of Comparative Psychology, 32: 217-231, October, 1941.

3. Howland, Carl I. "Experimental Studies in Rate-Learning Theory, VI, Comparison of Retention Following Learning to the Same Criterion by Massed and Distributed Practice", Journal of Experimental Psychology, 1940, 26: 568-587.

4. Cain, Leo F., and Willey, R. DeVerl, "The Effect of Spaced Learning on the Curve of Retention", Journal of Experimental Psychology, 1939, 25: 209-214.

practices than for those learned by massed practice. Re-learning scores were also better for the groups whose practice was spaced.

Analysis of the Literature

An analysis of the literature in this field shows that little has been done in relation to the study of time psycholoty. With the exception of Miller, no research has been carried on in which the normal learning situation has been reached. For the sake of analysis, however, material related to the subject has been presented for review.

CHAPTER III

PROCEDURE

The author's research for this reliability check was conducted at the Charlesgate Hall, a dormitory for Boston University women students. The data for 11 instead of 18 subjects were recorded due to the others having left school, graduated, or not being available at the time. This study was carried on one year after Miller conducted his research. A billiard table corresponding in dimensions to the billiard tables used by other experimenters in this field was made available.

The set shots[1] used in the research were taken from those that Miller carried on in his experiment. Set shot one used in this study is the same as Miller's set shot five and will be referred to frequently throughout the research. The billiard spots on the table were marked to assure that the position of the ball was always the same. The target balls were set up after each shot by the instructor. In this way variables were kept at a minimum. Twenty-four girls volunteered to aid in the experiment, but two were found to have played billiards within the

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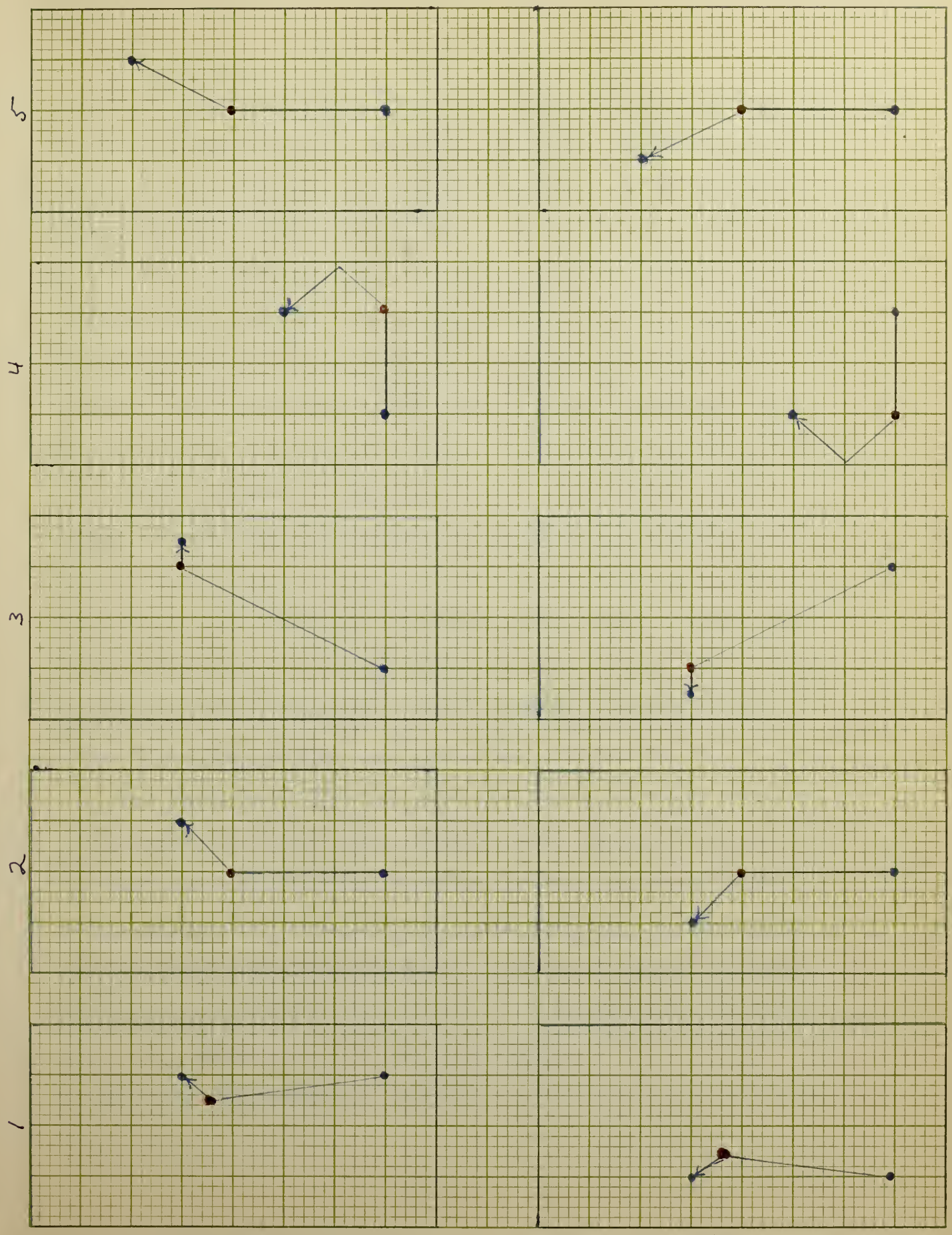
1. See Page 8

Chart I Set Shots 1, 2, 3, 4, 5, On Right and Left Sides of Table Respectively



period of a year, so they were not chosen to participate. The twenty-two subjects selected consisted of eleven girls from Miller's Group II, the Additive Group and eleven girls from Group III, the Daily Group.

The requirements made of the girls were as follows: (1) They were not allowed to practice at any time until the experiment was finished, (2) If a girl missed a practice session, she was disqualified and her data discarded, and (3) They were to attend the practice sessions in pairs.

Miller suggested the five shots to be used in his chapter on further research.[1] These five set shots[2] consisted of ten tries per shot, five on the right side, and five on the left side of the table. This made a total of fifty shots per practice period. In this manner the element of fatigue was eliminated. The interest of the subjects was high at all times.

The experiment started with the first practice session on February 15, 1949. The subjects were tested for a period of three consecutive days starting Tuesday and concluding on Thursday. By March 25, 1949, all girls had been tested and data was ready for analysis. Each girl performed 150 shots during the three day period or a grand total of 3300 shots were taken by all twenty-two girls.

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1. Miller's dissertation, page 55.

2. See Page 8

At the initial practice session some instruction was given to all subjects and consisted of method of handling of the cue stick, how and where to stand, and where the balls were to be hit. After the first practice period no corrective help or criticism was given. At no time during the experiment did the instructor hit the ball with the cue stick.

A score sheet[1] was used for recording the shots. A billiard resulted when the cue ball hit the red ball and then struck the other white ball. A check on the score sheet signified the billiard had been made, and a zero was indicative of a miss. A perfect score was ten per set shot. While one subject attempted the shot, the other subject recorded the score under the instructor's supervision. The experimenter placed the target balls on the proper spots and indicated the position of the cue ball.

Pertinent information regarding the conduct of the experiment also included the following: practice periods were carried on during the late afternoon and early evening. The average time required to complete the one hundred shots (fifty for each girl) was between twenty and thirty minutes.

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1. Sample score sheet is included in Appendix.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Significance of Data

The significance of the difference of the means is as follows: 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 (C.R.) 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 the mean gains of another group.

Summary of the Data[1]

A summary of the data for Miller's set shot five and Lawrence's set shot one for each of the two groups, including totals, ranges, means, and standard deviations is shown in Table I, (page 13) and II (page 14). The figures for the first and third practice periods were included in the tables but they were not used in the statistical treatment of the data. The reason for this is that the first practice period was used to instruct the subjects in certain techniques of playing billiards. Throughout this practice

1. The records of all the set shots for each of the two groups and their individual subjects are included in the Appendix, Tables XIV - XXI.

period, corrective suggestions were made by the instructor. The third practice period was found to indicate secondary learning and therefore was not considered pertinent to the problem of reliability. The data has been included in the tables but they have not been used in determining critical ratios.

One of the results found by Miller[1] was, "The results of set shot five for the four groups were similar to the results of all set shots for the group. In other words as far as results were concerned, the research might have been limited to set shot five for all the groups."

Longley found[2], "Set shot one makes a good common factor to compare practice patterns as it is a fair indicator of the total practice pattern."

With these conclusions in mind, it was therefore decided to use set shot one which is the same as Longley's set shot one, and Miller's set shot five, for comparative work with the groups.

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1. Miller, A. G. The Effect of Various Interpolated Time Patterns on Motor Learning. Doctor's Dissertation, Boston University, 1948, p.52.

2. Longley, G. F. The Effect of Massed Followed by Evenly Spaced Practice on Learning a Motor Skill. Master's Thesis, Boston University, 1948.

Table I

SUMMARY OF THE DATA OF SET SHOT FIVE FOR GROUP II, THE ADDITIVE GROUP AND GROUP III, THE DAILY GROUP--- MILLER(1) USING ONLY 11 SUBJECTS, INCLUDING: TOTALS, RANGES, MEANS, AND STANDARD DEVIATIONS

Practices	1	2	3	4	5	6	7	8	9	Totals (2)
Sub-Totals										
Group II (3)	50	57	79	60	73	74	76	70	78	576
Group III (4)	63	68	60	77	80	75	80	70	76	586
Ranges										
Group II	0-8	2-10	4-10	2-8	4-9	4-9	4-9	4-10	2-10	34-68
Group III	3-10	3-10	3-10	3-9	6-9	3-8	5-10	2-9	4-9	36-65
Means										
Group II	4.5	5.2	7.1	5.4	6.6	6.7	6.9	6.3	7.0	52.3
Group III	5.7	6.2	5.4	7.0	7.2	6.8	7.2	6.4	6.9	53.2
S. D.										
Group II	257	244	234	214	203	171	205	219	271	12.1
Group III	311	188	236	181	150	142	169	152	142	7.57

(1) From Miller's Dissertation
(2) Totals are for practice periods two through nine
(3) Group II - The Additive Group
(4) Group III - The Daily Group

Table II

SUMMARY OF THE DATA OF LAWRENCE'S SET SHOT ONE (SAME AS MILLER'S SET SHOT FIVE) FOR GROUP II, THE ADDITIVE GROUP AND GROUP III, THE DAILY GROUP, INCLUDING: TOTALS, RANGES, MEANS AND STANDARD DEVIATIONS

Practices	1	2	3	Totals(1) (2-3)
Sub-Totals				
Group II (2)	64	83	80	163
Group III (3)	65	67	84	151
Ranges				
Group II	3-9	4-10	5-9	11-19
Group III	3-8	3-8	6-10	10-18
Means				
Group II	5.8	7.5	7.2	14.8
Group III	5.9	6.0	7.6	13.7
S. D.				
Group II	2.79	2.17	1.53	2.51
Group III				

(1) Totals are for practice periods two and three
(2) Group II - The Additive Group
(3) Group III - The Daily Group

The mean scores for both groups covering the second and ninth practice periods of Miller, and the second period of Lawrence's recheck pattern are shown in Diagram I (page 16). Because the author gave instruction during the first session he would rule out the data for that period, and analyze the results of the experiment using the second or recheck practice period.

It will be noted that both groups showed an increase from the second practice session to the ninth practice period of Miller. The additive group, however, showed a much higher gain between the second and ninth practice periods than did the daily group. Again, in the recheck, the second practice period of Lawrence showed a mean score gain in favor of the additive group. It is highly significant to note that the degree of retention of Group II, The Additive Group, increased between the second practice period of Miller and the recheck session of Lawrence. In Group III, The Daily Group, however, there was an outstanding drop. This showed a loss of learning after a time interval of one year for the daily group in comparison with a growth in learning for the additive group.

Diagram I Mean Scores for Miller's Set Shot Five and Laurence's Set Shot One (Same) for Group II, The Additive Group as Compared to Same Mean Scores of Group III, The Daily Group.

Group	Practice	II Miller	III Miller
	2	5.2	6.2
	9	7.0	6.9

Group	Practice	II Laurence	III Laurence
	Recheck	7.5	6.0

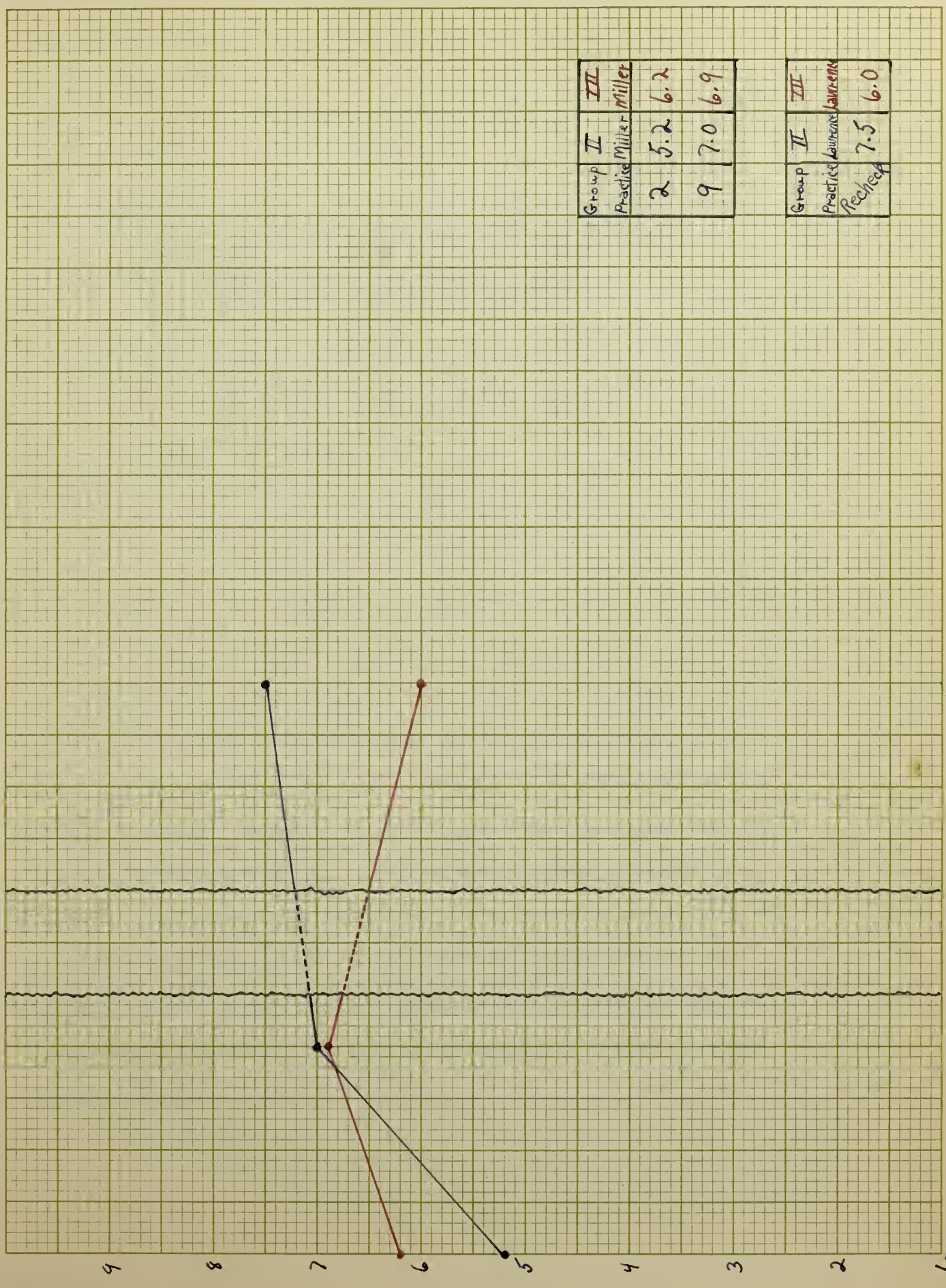


Table III

A SUMMARY OF THE DATA OF GROUP II, THE ADDITIVE GROUP FOR MILLER'S SECOND AND NINTH PRACTICE PERIOD AND LAWRENCE'S SECOND PRACTICE PERIOD INCLUDING: TOTALS, RANGES, MEANS AND STANDARD DEVIATIONS

GROUP II - THE ADDITIVE GROUP				
Practice Period	Totals	Ranges	Means	S. D.
M-2	57	2-10	5.2	2.44
M-9	78	2-10	7.0	2.74
L-2	83	4-10	7.5	2.17

The differences in means for Group II, The Additive Group show a highly significant gain over the mean differences for Group III, The Daily Group. The critical ratio between Miller's second and ninth practice session for the additive group was high. It dropped slightly between Miller's ninth session and Lawrence's recheck session. It is highly significant to note that the group showed the highest overall increase in learning from Miller's second (beginning) practice session to Lawrence's second recheck (final) practice session.

The Difference in Mean Scores of Set Shot Five (Miller) for Group II, the Additive Group.

Table IV

DIFFERENCE IN MEANS OF THE SECOND PRACTICE PERIOD AND THE NINTH PRACTICE PERIOD FOR GROUP II, THE ADDITIVE GROUP

Practice	Group	No.	Mean	SE_m	$D_{m_2 m_9}$	$S.E._D$	C.R.
M-2	II	11	5.2	.771	1.8	.759	2.37
M-9	II	11	7.0	.867			

The critical ratio of the difference between the means of the Second Practice Period and the Ninth Practice Period is 2.37. There are 99.2 chances out of 100 that the true difference is greater than zero, that is, there are 99.2 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.

The Difference in Mean Scores of Miller's Set Shot Five and Lawrence's Set Shot One (Same) for Group II, the Additive Group.

Table V

DIFFERENCE IN MEANS OF MILLER'S NINTH PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK FOR GROUP II, THE ADDITIVE GROUP

Practice	Group	No.	Mean	SE_m	$D_{m_9 m_2}$	S.E.$_D$	C.R.
M-9	II	11	7.0	.867	.5	.624	.80
L-2	II	11	7.5	.683			

The critical ratio of the difference between the means of Miller's Ninth Practice Period and Lawrence's Reliability Check is .80. There are 78.8 chances out of 100 that the mean of the last practice is greater than the mean of the ninth practice period for the additive group.

The Difference in Mean Scores of Miller's Set Shot Five and Lawrence's Set Shot One (Same) for Group II, the Additive Group.

Table VI

DIFFERENCE IN MEANS OF MILLER'S SECOND PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK FOR GROUP II, THE ADDITIVE GROUP

Practice	Group	No.	Mean	SE_m	$D_{m_{2_m} m_{2_L}}$	$S.E._D$	C.R.
M-2	II	11	5.2	.771	2.3	.699	3.29
L-2	II	11	7.5	.683			

The critical ratio of the difference between the means of Miller's Second Practice Period and Lawrence's Reliability Check is 3.29. There are 99.9 chances out of 100 that the true difference is greater than zero, that is, there are 99.9 chances out of 100 that the mean of the last practice is greater than the mean of Miller's second practice period for the additive group.

Diagram II Mean Scores of Miller's Set Shot Five and Lawrence's Set Shot One for Group II. The Additive Group.

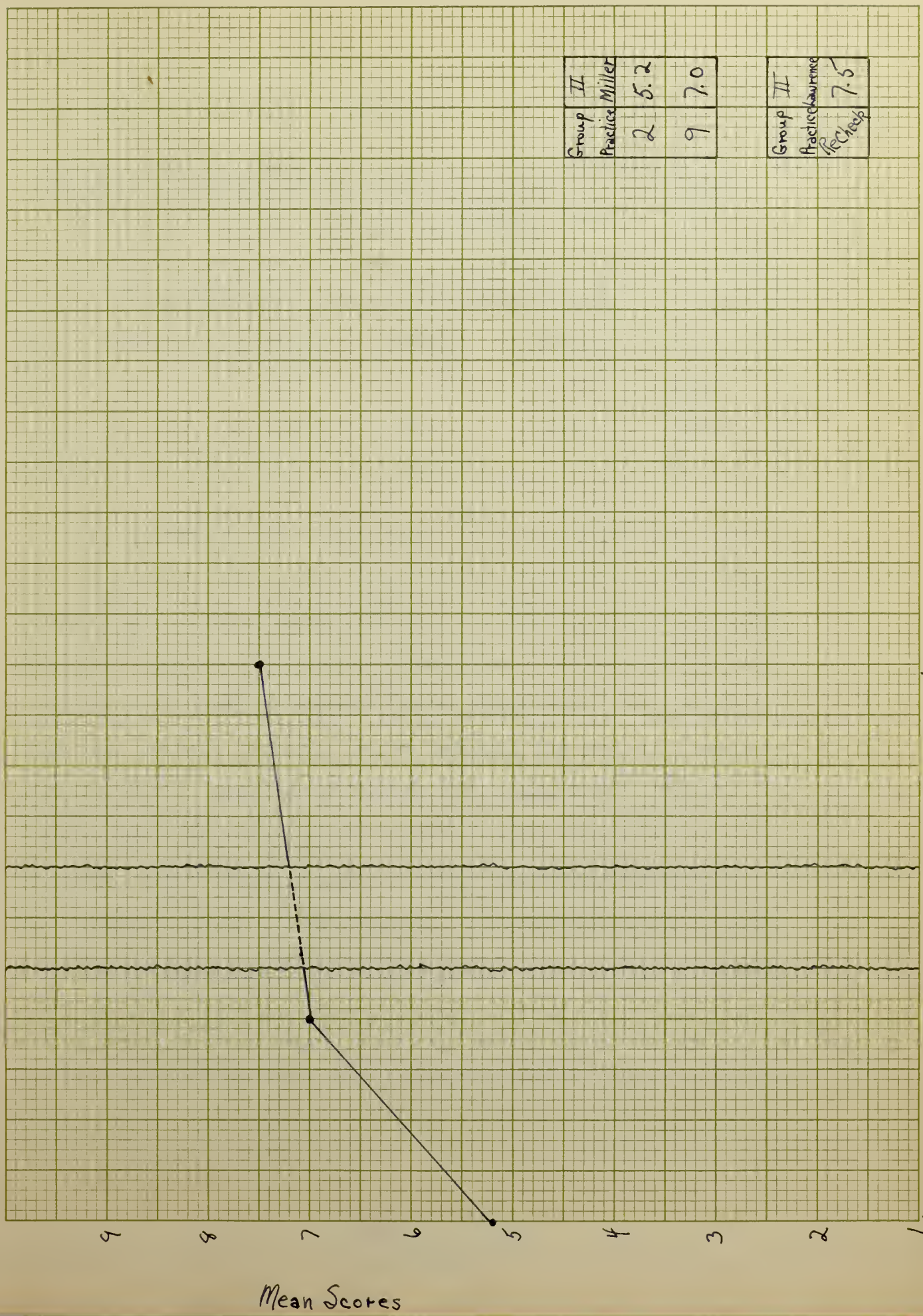


Table VII

A SUMMARY OF THE DATA OF GROUP III, THE DAILY GROUP FOR MILLER'S SECOND AND NINTH PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK INCLUDING: TOTALS, RANGES, MEANS AND STANDARD DEVIATIONS

Group III --- The Daily Group				
Practice Period	Totals	Ranges	Means	S.D.
M-2	68	3-10	6.2	1.88
M-9	76	4-9	6.9	1.42
L-2	67	3-8	6.0	1.93

In examining the differences in mean scores for Group III, the Daily Group, two interesting facts were observed. Between the Ninth Practice Session of Miller and the Second Practice Session of Lawrence there was a slight loss in retention of learning. However more significant is the fact that the overall learning curve between the second (beginning) practice session of Miller and the second (final) session with Lawrence shows a drop in the retention of ability. This clearly seems to show the superiority of the additive group, which showed a significant gain in the overall learning curve, over the daily group, which dropped.

The Difference in Mean Scores of Set Shot Five (Miller) for Group III, the Daily Group.

Table VIII

DIFFERENCE IN MEANS OF THE SECOND PRACTICE PERIOD AND THE NINTH PRACTICE PERIOD FOR GROUP III, THE DAILY GROUP

Practice	Group	No.	Mean	SE_m	$D_{m_2 m_9}$	S.E.$_{D_{m_2 m_9}}$	C.R.
M-2	III	11	6.2	.594	17	.429	1.63
M-9	III	11	6.0	.449			

The critical ratio of the difference between the means of the Second Practice Period and the Ninth Practice Period is 1.63. There are 95.1 chances out of 100 that the true difference is greater than zero, that is, there are 95.1 chances out of 100 that the mean of the last practice is greater than the mean of the second practice period for the daily group.

The Difference in Mean Scores of Miller's Set Shot Five and Lawrence's Set Shot One (Same) for Group III, the Daily Group.

Table IX

DIFFERENCE IN MEANS OF MILLER'S NINTH PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK FOR GROUP III, THE DAILY GROUP

Practice	Group	No.	Mean	SE_m	$D_{m_9 m_2}$	$S.E._D$	C.R.
M-9	III	11	6.9	.449	-.9	.742	1.21
L-2	III	11	6.0	.611			

The critical ratio of the difference between the means of Miller's Ninth Practice Period and Lawrence's Reliability Check is -1.21. There are 88.5 chances out of 100 that the true difference is greater than zero, that is, there are 88.5 chances out of 100 that the mean of the last practice is less than the mean of the ninth practice period for the daily group.

The Difference in Mean Scores of Miller's Set Shot Five and Lawrence's Set Shot One (Same) for Group III, the Daily Group.

Table X

DIFFERENCE IN MEANS OF MILLER'S SECOND PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK FOR GROUP III, THE DAILY GROUP

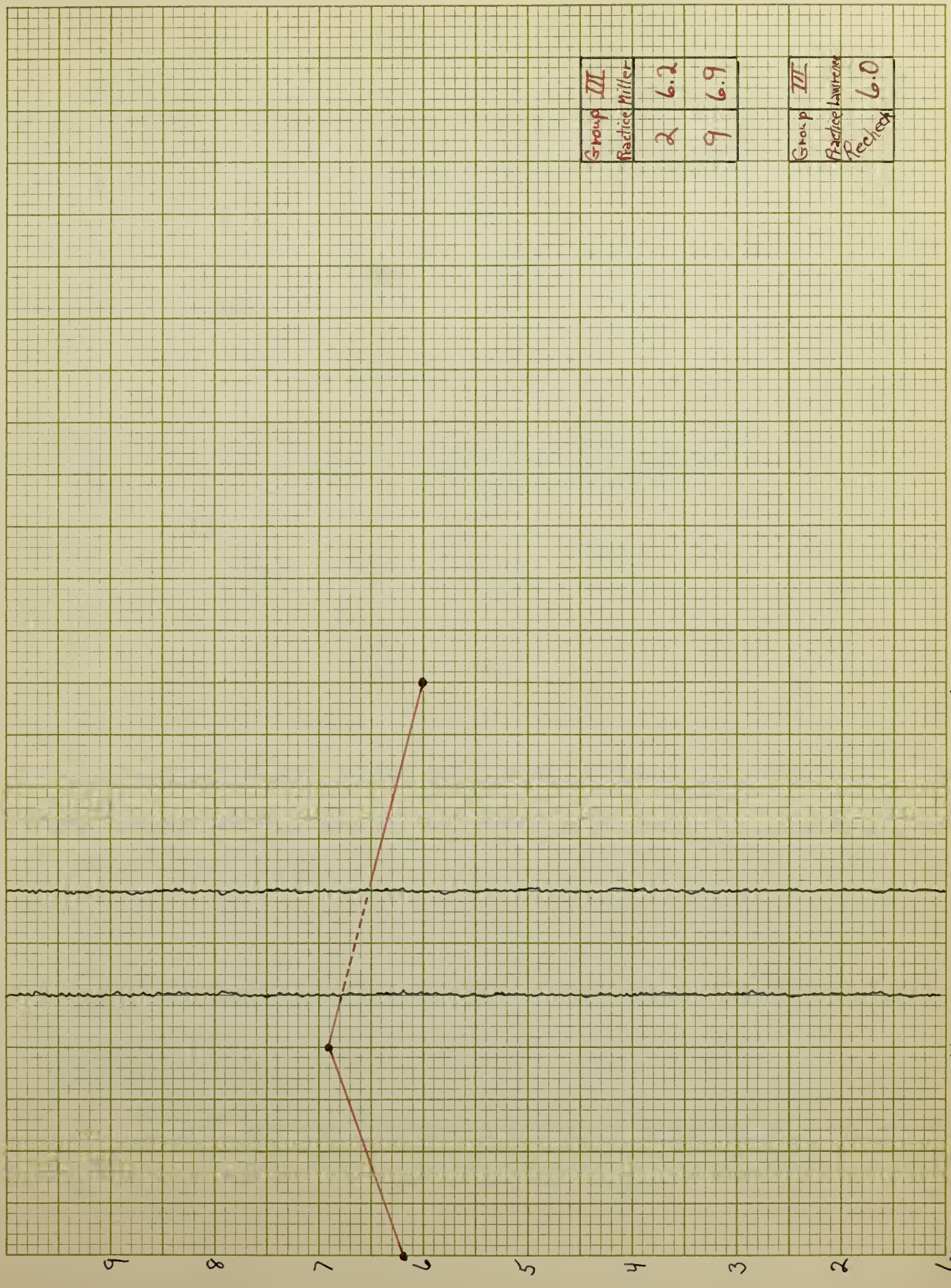
Practice	Group	No.	Mean	SE_m	$D_{m_2 m_2}$	S.E.$_D$	C.R.
M-2	III	11	6.2	.594	-.2	.529	.37
L-2	III	11	6.0	.611			

The critical ratio of the difference between the means of Miller's Second Practice Period and Lawrence's Reliability Check is -.37. There are 63.7 chances out of 100 that the true difference is greater than zero, that is, there are 63.7 chances out of 100 that the mean of the last practice is less than the mean of Miller's second practice period for the daily group.

Diagram III Mean Scores of Miller's Set Shot Five and Lawrence's Set Shot One for Group III., The Daily Group.

Group III Miller	
Practice	6.2
2	6.9
9	

Group III Lawrence	
Practice	6.0
Recheck	



The Difference in Mean Gains of Miller's Set Shot Five and Lawrence's Set Shot One (Same) for Group II, the Additive Group and Group III, the Daily Group.

Comparisons of the mean gains of the individual groups are shown in Tables XI to XIII.

Table XI

DIFFERENCE IN MEAN GAINS OF MILLER'S SET SHOT FIVE FOR GROUP II, THE ADDITIVE GROUP AND GROUP III, THE DAILY GROUP FOR THE SECOND AND NINTH PRACTICE PERIODS

Group	No.	D_{mg}	SE_{mg}	$D_{mg_2-mg_9}$	$S.E._D$	C.R.
II	11	1.8	.759	1.1	.872	1.26
III	11	.7	.429			

The critical ratio of the difference of the mean gains between the Additive Group and the Daily Group for the second and ninth practice periods on set shot five is 1.26. There are 89.5 chances out of 100 that the true difference in mean gains is greater than zero, that is, there are 89.5 chances out of 100 that the mean gain of the additive group is greater than the mean gain of the daily group for the ninth practice session.

Table XII

DIFFERENCE IN MEAN GAINS FOR GROUP II, THE ADDITIVE GROUP, AND GROUP III, THE DAILY GROUP FOR MILLER'S NINTH PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK

Group	No.	D_{mg}	SE_{mg}	$D_{mg_9-mg_2}$	$S.E._D$	C.R.
II	11	.5	.624	1.4	.970	1.44
III	11	-.9	.742			

The critical ratio of the difference of the mean gains between the Additive Group and the Daily Group for Miller's ninth practice period and Lawrence's reliability check using set shot five and set shot one (the same) is 1.44. There are 92.5 chances out of 100 that the true difference in mean gains is greater than zero, that is, there are 92.5 chances out of 100 that the mean of the additive group is greater than the mean of the daily group for the last practice period.

Table XIII

DIFFERENCE IN MEAN GAINS FOR GROUP II, THE ADDITIVE GROUP, AND GROUP III, THE DAILY GROUP FOR MILLER'S SECOND PRACTICE PERIOD AND LAWRENCE'S RELIABILITY CHECK

Group	No.	D_{mg}	SE_{mg}	$D_{mg_2-mg_2}$	$S.E._D$	C.R.
II	11	2.3	.699	2.5	.876	2.87
III	11	-.2	.529			

The critical ratio of the difference of the means gains between the Additive Group and the Daily Group for Miller's second practice period and Lawrence's reliability check using set shot five and set shot one (the same) is 2.87. There are 99.8 chances out of 100 that the true difference in mean gains is greater than zero, that is, there are 99.8 chances out of 100 that the mean of the additive group is greater than the mean of the daily group for the last practice session.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Two groups of undergraduate college women were retested in the fundamentals of billiards. There were three practice periods during which each subject attempted fifty shots. All conditions and factors remained constant for both groups throughout the experiment.

Five set shots were used for this experiment. A practice period consisted of two subjects, each taking ten tries, five on the right side and five on the left side of the billiard table. This made a total of fifty shots per practice period. The three practice periods were held on Tuesday, Wednesday, and Thursday for a period of four weeks. Only set shot one, which was similar to Miller's set shot five was used in treatment of the data. The first practice session was used for instruction and the third practice was considered relearning. Therefore practice session two was used for the reliability check.

At the conclusion of the research period all data was treated statistically and then analyzed.

The purpose of this study was to make a reliability check and ascertain the degree of retention between massed-spaced, i.e. additive interpolated learning in comparison

with massed learning. Group II, the Additive Group represented the massed interpolated spaced pattern while the pattern of massed learning was shown by Group III, the Daily Group.

At the conclusion of the experiment, the differences between the two groups were shown with these results:

1. The additive time pattern showed the best results in degree of retention. The mean gains of this pattern showed a statistically significant difference in comparison to the mean gains of the daily pattern.
2. The results of the daily group showed that learning decreased from the initial period to the recheck period. The mean scores at the beginning of the learning period were higher than the mean scores of Lawrence's reliability check or the final practice period.

Conclusions

1. In this type of research in which a reliability check is made, three shots other than the ones used in the experiment itself should be in the first recheck practice session. These are for instructional purposes and eliminate chance of secondary learning.

2. A third practice period is unnecessary in checking reliability. However a continuation of these practices might prove beneficial in securing data on relearning.
3. There were statistically significant differences in the final results in favor of the additive pattern over the daily pattern. It might be said that the retention in a massed interpolated spaced learning pattern of a motor skill (billiards) proved to be superior to the retention of a motor skill learned by a massed learning pattern.
4. Further research of this type should be conducted as all of the original subjects were not used in the reliability check.

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APPENDIX

Table XIV

RAW SCORES OF MILLER'S SET SHOT FIVE FOR (11) INDIVIDUAL SUBJECTS IN GROUP II, THE ADDITIVE GROUP

Names	No.	1	2	3	4	5	6	7	8	9	*Sub Totals
K. E.	1.	8	9	10	8	8	7	7	9	10	68
C. C.	2.	6	7	6	6	9	9	9	10	11	66
H. K.	3.	6	10	9	7	8	9	8	8	7	66
M. B.	4.	3	5	8	7	8	7	9	8	8	60
A. M.	5.	0	6	9	7	8	6	9	5	8	58
E. U.	6.	6	2	6	7	7	8	7	6	10	53
R. P.	7.	1	2	9	6	6	6	8	6	8	52
E. Z.	8.	6	4	7	2	6	8	4	6	6	43
C. L.	9.	4	4	5	3	4	5	5	4	4	39
L. E.	10.	6	4	4	5	5	5	5	4	5	37
S. G.	11.	5	4	6	2	4	4	5	4	2	34
Totals		50	57	79	60	73	74	76	70	78	576
Means		4.5	5.2	7.1	5.4	6.6	6.7	6.9	6.3	7.0	52.3
Ranges		0-8	2-10	4-10	2-8	4-9	4-9	4-9	4-10	2-10	34-68
S. D.		2.57	2.44	2.34	2.14	2.03	1.71	2.05	2.19	2.74	12.1

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 through 9

Table XV

RAW SCORES OF LAWRENCE'S SET SHOT ONE (SAME AS MILLER'S SET SHOT FIVE) FOR (11) INDIVIDUAL STUDENTS IN GROUP II, THE ADDITIVE GROUP

Names	No.	1	2	3	*Sub Totals
K. E.	1.	8	10	9	19
A. M.	2.	8	10	7	17
C. L.	3.	7	8	9	17
C. C.	4.	9	9	7	16
E. Z.	5.	5	9	7	16
H. K.	6.	8	7	8	15
E. U.	7.	5	6	8	14
M. B.	8.	5	7	7	14
L. E.	9.	2	7	6	13
S. G.	10.	4	6	5	11
R. P.	11.	3	4	7	11
Totals		64	83	80	163
Means		5.8	7.5	7.2	14.8
Ranges		3-0	4-10	5-9	11-19
S. D.		2.79	2.17	1.53	2.51

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 and 3

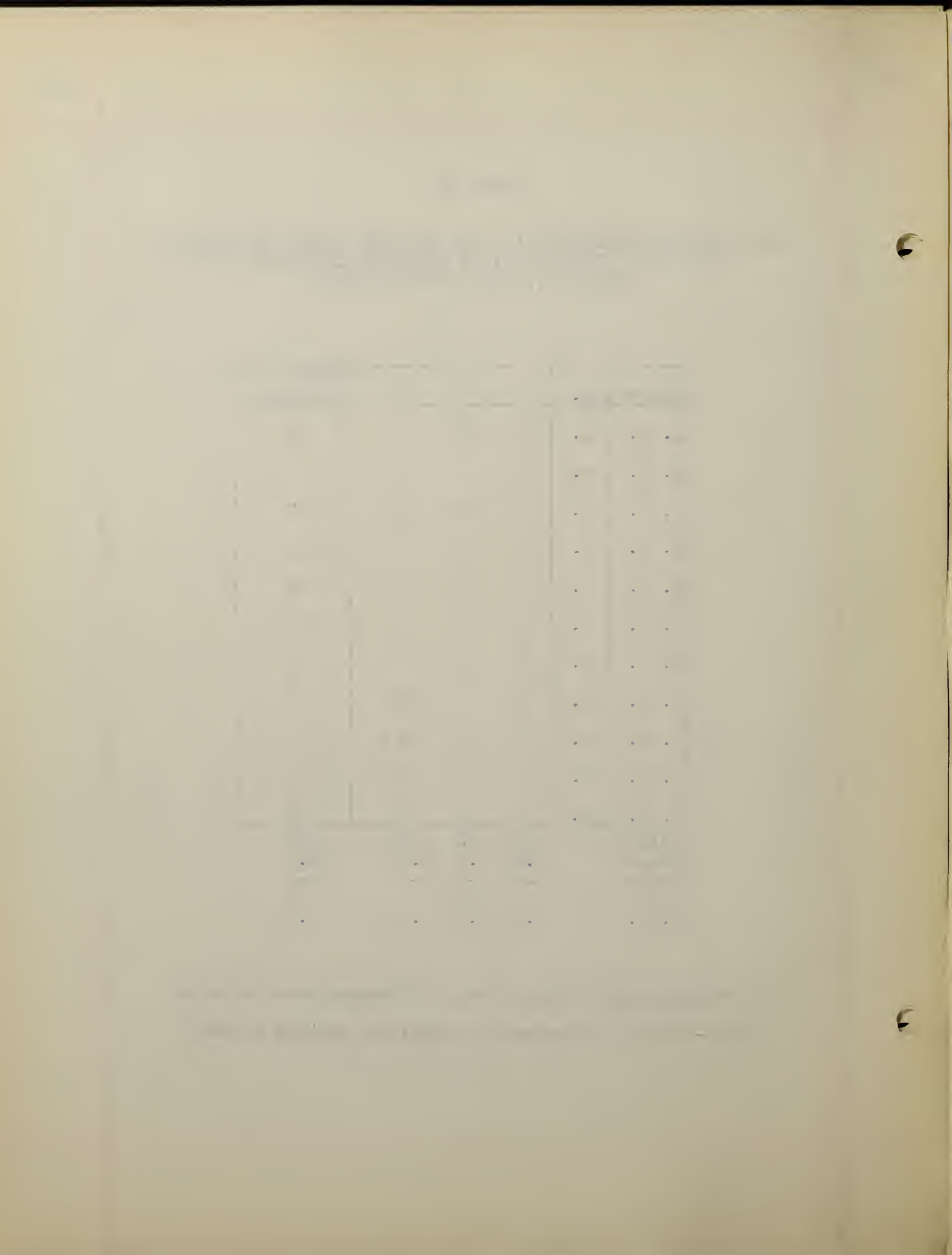

Table XVI

RAW SCORES OF MILLER'S SET SHOT FIVE FOR (11) INDIVIDUAL SUBJECTS IN GROUP III, THE DAILY GROUP

Names	No.	1	2	3	4	5	6	7	8	9	*Sub Totals
M. H.	1.	10	8	9	9	7	8	9	7	8	65
J. E.	2.	8	6	7	6	7	8	8	6	9	57
D. M.	3.	5	10	4	7	8	7	8	6	7	57
D. P.	4.	7	7	4	6	8	7	7	9	8	56
M. C.	5.	6	4	6	9	9	7	10	6	5	56
J. M.	6.	4	5	10	9	6	8	7	5	6	56
M. S.	7.	6	7	5	6	8	6	7	8	7	54
J. R.	8.	8	5	4	9	8	7	5	7	7	52
P. K.	9.	6	8	3	6	6	7	6	7	8	51
E. S.	10.	5	3	5	7	7	7	6	7	4	46
E. D.	11.	3	5	3	3	6	3	7	2	7	36
Totals		63	68	60	77	80	75	80	70	76	586
Means		5.7	6.2	5.4	7.0	7.2	6.8	7.2	6.4	6.9	33.2
Ranges		3-10	3-10	3-10	3-9	6-9	3-8	5-10	2-9	4-9	36-65
S. D.		3.11	1.88	2.36	1.81	1.50	1.42	1.69	1.52	1.42	7.57

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 through 9

Table XVII

RAW SCORES OF LAWRENCE'S SET SHOT ONE (SAME AS MILLER'S SET SHOT FIVE) FOR (11) INDIVIDUAL STUDENTS IN GROUP III, THE DAILY GROUP

Names	No.	1	2	3	*Sub Totals
D. M.	1.	3	8	10	18
J. E.	2.	7	8	8	16
J. R.	3.	8	8	8	16
D. P.	4.	6	7	8	15
M. C.	5.	5	6	8	14
M. S.	6.	8	7	7	14
E. S.	7.	6	6	8	14
M. H.	8.	8	5	8	13
P. K.	9.	6	5	6	11
J. M.	10.	5	4	6	10
E. D.	11.	3	3	7	10
Totals		65	67	84	151
Means		5.9	6.0	7.6	13.7
Ranges		3-8	3-8	6-10	10-18
S. D.		1.84	1.93	2.80	2.60

Subjects were college women undergraduate students

*Sub-Totals for scores in practice sessions 2 and 3

Table XVIII

RAW SCORES OF ALL SET SHOTS FOR (11) INDIVIDUAL SUBJECTS IN MILLER'S GROUP II, THE ADDITIVE GROUP

Names	No.	1	2	3	4	5	6	7	8	9	*Sub Totals
C. C.	1.	35	37	34	28	38	31	30	33	39	270
K. E.	2.	41	34	39	33	30	28	30	38	38	270
E. U.	3.	27	27	36	30	33	31	25	23	38	253
H. K.	4.	32	37	34	33	33	25	26	25	35	248
M. B.	5.	26	22	43	29	34	28	35	24	31	246
E. Z.	6.	25	33	35	17	27	28	20	18	34	212
A. M.	7.	9	27	33	21	24	23	25	23	33	209
C. L.	8.	27	21	25	16	23	19	16	19	30	196
R. P.	9.	9	13	35	25	19	23	22	21	19	196
L. E.	10.	30	26	21	17	22	23	18	9	23	189
S. G.	11.	15	20	24	20	17	15	25	25	20	181
Totals		276	297	358	269	300	274	272	258	350	2470
Means		25.1	27.0	32.5	24.4	27.2	24.9	24.7	23.4	31.8	224.5
Ranges		9-41	13-37	21-43	16-33	17-38	15-31	16-35	9-38	20-39	181-270
S. D.		9.56	7.26	7.00	6.42	6.79	4.78	5.46	7.39	5.92	26.1

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 through 9

Table XIX

RAW SCORES OF ALL SET SHOTS FOR (11) INDIVIDUAL SUBJECTS IN LAWRENCE'S RELIABILITY CHECK FOR GROUP II, THE ADDITIVE GROUP

Names	No.	1	2	3	*Sub Totals
C. C.	1.	34	36	36	72
K. E.	2.	31	35	32	67
A. M.	3.	21	34	26	60
H. K.	4.	23	28	29	57
C. L.	5.	28	25	32	57
E. Z.	6.	12	30	26	56
M. B.	7.	24	29	24	53
E. U.	8.	20	23	24	47
L. E.	9.	22	22	23	45
S. G.	10.	13	23	20	43
R. P.	11.	16	19	21	40
Totals		249	304	293	597
Means		22.6	27.6	26.6	54.2
Ranges		13-34	19-36	20-36	40-72
S. D.		6.15	5.64	5.00	9.93

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 and 3

Table XX

RAW SCORES OF ALL SET SHOTS FOR (11) INDIVIDUAL SUBJECTS IN MILLER'S GROUP III, THE DAILY GROUP

Names	No.	1	2	3	4	5	6	7	8	9	*Sub Totals
M. H.	1.	40	43	39	37	32	32	31	30	35	279
D. P.	2.	32	29	36	22	29	29	27	32	35	271
J. M.	3.	25	29	43	32	34	31	23	19	33	269
D. M.	4.	33	42	30	33	30	29	26	35	34	259
J. E.	5.	35	35	40	29	29	27	23	27	32	240
J. R.	6.	28	31	34	32	29	28	20	23	35	232
M. C.	7.	31	24	35	33	28	21	32	23	31	227
M. S.	8.	26	32	29	25	28	28	24	27	31	224
P. K.	9.	31	34	31	26	21	25	25	23	32	217
E. S.	10.	27	28	28	28	28	19	21	26	33	211
E. D.	11.	17	20	17	20	27	16	17	14	26	157
Totals		325	347	362	317	315	285	269	279	357	2586
Means		29.5	31.5	32.9	28.8	28.6	25.9	24.4	25.3	32.4	235.0
Ranges		17-40	20-43	17-43	20-37	21-34	16-32	17-32	14-35	26-35	157-279
S. D.		8.68	6.78	8.17	4.90	3.40	4.93	4.57	5.92	3.12	33.9

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 through 9

Table XXI

RAW SCORES OF ALL SET SHOTS FOR (11) INDIVIDUAL SUBJECTS IN LAWRENCE'S RELIABILITY CHECK FOR GROUP III, THE DAILY GROUP

Names	No.	1	2	3	*Sub Totals
J. E.	1.	28	33	34	67
D. M.	2.	21	30	33	63
M. H.	3.	28	29	30	57
D. P.	4.	28	26	30	56
M. C.	5.	20	26	28	54
J. R.	6.	24	27	24	51
E. S.	7.	23	22	20	42
P. K.	8.	23	22	19	41
M. S.	9.	32	18	22	40
J. M.	10.	16	17	30	37
E. D.	11.	17	14	23	37
Totals		260	264	293	547
Means		23.6	24.0	26.6	49.7
Ranges		16-32	14-33	19-34	37-67
S. D.		4.94	5.65	5.18	10.5

Subjects were college women undergraduate students

*Sub-Totals for scores in practice periods 2 and 3

BILLIARD SCORES

NAME:_____ DATE:_____ TIME:_____

GROUP: TEST:

Shot No.	Right Side Scores	Totals	Left Side Scores	Totals
	Total Right Side Score		Total Left Side Score	

✓ Successful Shot

0 Unsuccessful Shot

Total Right Side Score	
Total Score	

BILLIARD SCORES

NAME:_____ DATE:_____ TIME:_____

GROUP: TEST:

Shot No.	Right Side Scores	Totals	Left Side Scores	Totals
	Total Right Side Score		Total Left Side Score	

✓ Successful Shot

0 Unsuccessful Shot

Total Right Side Score	
Total Score	