THE EFFECT OF MENTAL PRACTICE ON THE DEVELOPMENT OF A CERTAIN MOTOR SKILL

by

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PREFACE

The author questions that the pattern of experiences, thoughts, ambitions, and frustrations that have combined over a long period of years to influence the thinking that finally evolved into the dissertation at hand can be properly put down on paper, but a strong feeling exists that this dissertation "has been in the making," so to speak, since early boyhood. It has been considered important to at least point out what appear to be the contributing factors.

One thing is certain, and that is that the desire to search out the answer to this particular dissertation problem became a strong one long before any thought was ever given to studying for a doctorate, and that only when it became apparent that a particular type of training was needed if the solution was to be found. The interest in this problem has been the driving force behind participation in the doctoral program of study. Perhaps it has been "putting the cart before the horse," as several educators have suggested, but the determination to find the answer to it has been such a strong one that it has been the inspiration that has spurred the author on when the more pedestrian approach of just getting a degree might long ago have caused interest in the program to pall and die.

The author, at an early age, came to wonder about the importance of will power in one's life because of a combination of factors and events. A bout with double pneumonia at the age of four was such a critical one that during the "crisis" the pulse stopped for a time and long enough so that the doctor had just about decided that death had occurred when the heart resumed beating. The struggle back to good health was a long one. The pre-adolescent and adolescent periods were noteworthy for extremely rapid growth into a tall, gangling youngster who had developed a determination to achieve good health and a powerful physique. Newspaper dramatizations of athletes who had overcome large handicaps to attain athletic greatness left a deep impression. During this period a personal definition of will power was formulated which is still subscribed to, and that was: Will power is the application of frequent deep thought to analyzing the conditions so as to determine a logical and definite course of action that presents a possible solution to a critical problem in a person's life, followed by the continual application of intense determination and effort to carrying out the course of action that has been decided upon. This formula for living became embodied in an intense pattern of effort, an exhilarating drive on the part of the author himself, to develop into a versatile and outstanding athlete, if possible.

During the latter part of the grade-schooling period, the author came under the influence of Chilton Kemp, a physical educator of vision way in advance of his time. One of his innovations was the introduction of the idea of well-coached seventh and eighth grade basketball teams into the local school system, and shortly thereafter a basketball league between the two local grade schools. The stimulation from this activity resulted in several youngsters joining in the mutual objective of starting to practice toward the winning of a state basketball championship when promotion into high school had been achieved. Hundreds of hours were spent practicing in an old barn at shooting over a high beam to learn how to "arch our shots," because it had been agreed that such practice would be good preparation for the day when the opportunity to play on large tournament floors with high ceilings might develop. High school and semi-professional basketball games were attended regularly so that the various shooting forms, passing, and play techniques might be observed. The ideas thus obtained were worked on in the old barn during weekends. Analyzing the movements of playmates during these practice sessions, and even lying in bed nights trying to visualize or "see in the mind's eye" manuevers seen at games and how they might be utilized, became a habit. This process of visualizing or "picturing motor skills in the mind's eye" was employed more and more during progress in athletics.

About the time of the author's initial participation in high school football, Knute Rockne's reputation as a football coach came to make a tremendous impression on him. Articles about Knute were read avidly, and every moving picture show at the local theatre that carried even a short newsreel about his nationally famous football teams was attended. The focusing of attention on minute detail as to the proper positioning of the body, and in execution of plays, left the impression that Rockne was training his boys to carefully perceptualize their every manuever.

During the author's last season in football at Bates College, Lewiston, Maine, Adam Walsh, one of Knute Rockne's finest proteges, was enjoying phenomenal success in his first season with the Bowdoin College, Brunswick, Maine, football team. It was general knowledge that Walsh, after the first game of the season, rarely ever had his players scrimmage during practice sessions, that they were kept busy instead practicing the execution of minute detail in blocking, running, passing, kicking, and play patterns; that he was, apparently in the ways of his own college coach, Rockne, teaching his players the importance of thinking in the execution of motor skills. While playing against the Walsh-coached team in the last game of the season, the author had an opportunity to experience first-hand the effectiveness of this type of coaching, and was very much impressed by the fact that a seemingly physically inferior team just ran away with the game as a result of the excellence of their play.

This same year, during discussions of anatomy under Dr. Fred Pomeroy, Professor of Biology, Bates College, Lewiston, Maine, a deep interest developed in the anatomy and functions of the human brain, and especially in the theories of the day as they were concerned with the question of whether or not specific areas had to do with control of specific functions of the body. It is recalled that at that time frequent thought had been given to the possibility of training parts of the brain to take over for areas that were injured or destroyed, and also to the question whether the control of the functions of the body were as strictly confined to local areas of the brain as it seemed. What caused right-handedness, left-handedness, ambidexterity, and what were the possibilities of employing "transfer of training" in teaching motor skills were frequent subjects of thought.

Graduation from college was followed by entrance into the high school coaching profession. The first season presented the problem of attempting to develop a good basketball team sans a gymnasium, and with the team getting only a few hours of practice a week in an old, second-floor moving picture theatre through an agreement that permitted the team to use the hall providing it moved the seats out for the practice sessions, and then back into their proper positions at the termination of practice. There was the additional effort of putting up and taking down portable backboards. This small school was in a basketball league with several much larger high schools, and had not won a championship in twenty-three years. Imbued with the spirit of wanting very much to produce a winning team, and with the additional incentive of competing against the team of the coach under whom the author had played four years previously to a state championship, the boyhood goal aforementioned finally attained, the author decided that it would be necessary to develop some special techniques to overcome the many obvious obstacles the players were faced with if even a few games were to be won.

For extra conditioning, the players were persuaded to hike, run, hunt, skate, and ski weekends, or whenever the opportunity presented itself.

To compensate for the much fewer number of practice hours per week this team had than its rivals, it was decided to try out an idea that had developed from observations of the coaching technique of both Knute Rockne and Adam Walsh, and that was to spend a considerable portion of each practice session striving to get the players to "picture in their mind's eye" the various playing techniques to be used. This procedure was followed with individual plays, and with play patterns. During rehearsal of plays, and also scrimmages, the procedure was for the instructor to whistle on spotting a mistake. Each player was to then attempt to stop within two steps, retrace them, and then look at the positions of the other players and attempt to discern from their positions what the mistake had been that the coach had in mind. When this was determined, the players were asked to make suggestions. Instructions were then given as to the execution desired. The players were now required to walk slowly through the manuever while at the same time they were asked to make a "mental picture" of the correct execution of it.

As this squad was faced with the problem of competing against much taller teams, it was decided a worthwhile consideration to develop "trick" shots that might conceivably compensate for the team's height disadvantage. Two of the forwards became amazingly proficient in "faking" a shot, then stepping quickly and directly away from the basket and "laying" the ball back over the shoulder with only a fleeting glance at the basket during release of the ball. All the forwards were taught to take certain steps away from the restraining lines of the foul line area, and to combine these measured steps with concentration on the "muscular feel" of the ball, plus a mental image of the basket in relation to the particular position on the floor the player was in as a result of these measured steps. These players were to all outward appearances shooting blindly over the shoulder, but actually were guided in their shooting by a known position on the floor, a developed "muscular feel" of the ball for that particular shot relative to said position, and also by a mental image of the basket in relation to the player's floor position. The fleeting glance taken during the final completion of the shot no doubt played some part in the accuracy. The results of this strategy were surprising, as this team won the first league title for this school in twenty-three years. It lost only one game to a high school team during the entire season, a heartbreaking "two-pointer," to the Maine State Class-A Champions, and that in the final ten seconds of the game.

This coaching technique was employed with success during the years leading up to the author's entrance into the United States Navy for World War II, at which time he became an Athletic Specialist engaged in conditioning and training men for amphibious attack. This activity was pursued for approximately seven months, when an assignment was received for training as a Specialist in Physical Rehabilitation in the new program initiated by the Navy at that time. Following this period of special training, an assignment to the staff of the U. S. Naval Hospital in Newport, Rhode Island, was received.

Approximately six months of service had been completed at this hospital developing a rehabilitation program for cases in the mental ward, and also a new rehabilitation technique for the promotion of early ambulancy of cases of herniotomies and appendectomies, when an incident occurred in the hernia ward that was to touch off a definite chain of events leading up to the author's decision to undertake a doctoral program of study.

A tall, handsome marine, who had suffered a brain puncture from shrapnel, and also a badly mangled right shoulder during the battle for the Iwo Jima Airport, was assigned a bed in this particular ward. His wounds had resulted in partial paralysis, especially of the right arm and leg. Incapacitation was such that he could not even feed himself. This patient had evidently been intently watching the author supervise hernia cases in a special exercise routine that had been designed to ward off the debilitating effects that formerly had been accepted as the inevitable result of such an operation. One day he asked, "Hey, Doc, what are my chances of getting well?" Knowing that the prognosis on this patient's condition was very discouraging, but with a large number of patients in the ward listening, in addition to several nurses and a medical doctor, the only answer that could be thought of at the time to meet a situation so charged with pathos was given, and that was, "Eddie, all I feel I can say to your question is that where there is a will, there is a way."

The next morning, while engaged in rehabilitation work with the hernia cases, the author was approached by the neurosurgeon in charge of the patient aforementioned. He asked, "Are you the Specialist who spoke to Eddie yesterday?" An affirmative reply was given. "Will you consider working with him?" he then asked. The answer was a startled one. "What can a specialist in physical rehabilitation do that an expert neurosurgeon cannot do much better?" The reply was to the effect that the previously mentioned remark to the patient about will power coupled with the patient's observations of the work being done with the hernia cases had given this boy a tremendous confidence that he might also be helped to get well. Astounded, but happily pleased, the author accepted the proffered proposition of attempting to do something to help this patient.

As a coach the author had studied and worked at methods of doing the kinds of physiotherapy that are within the province of an athletic trainer, and had developed some skill, and a number of ideas on the subject. This background was now of great value.

During the next few days, the patient was given infrared heat treatments, massaged, and then his limbs manipulated into various positions to determine how much restriction there was as a result of the paralysis and of scar tissue.

Just how much the facts, as described above, and how much intuition played a part, is not known, but after deep thought on the problem at hand for several days, the author developed a line of action. The patient's right arm and hand were partially paralyzed as a result of a puncture in the left side of the brain. In addition, the arm was also considerably restricted in mobility because his right shoulder had been badly shot up with a resulting formation of a considerable amount of scar tissue. When the patient attempted to evert or move the right hand in any normal direction, a spastic type movement resulted, with the arm and hand always ending up in the same position, flexed tightly across the front of the body. The left arm and hand were much more mobile, and with more normal sensation than the right arm. The patient, with left arm and hand placed on the bed in front of him, was asked to slowly evert them while at the same time to concentrate on the "muscular feel" of the motion. He was then asked to attempt the difficult psychological feat of transferring in his mind this feeling of eversion left of the left limb so as to imagine sensing it instead as one of eversion right of the right arm and hand. He was also asked to concentrate on the thought, "I am turning my right hand outward," while at the same time fixing his gaze on said right hand and arm. The right arm and hand were manipulated outward by the therapist as the patient went through the above thought process. The patient was cautioned to make no physical effort to turn the right hand. It had been decided that for the patient to exert any physical effort on this particular motion at this time would only serve to strengthen the responding nerve and muscle groupings in the incapacitated limb, and thus create a greater imbalance between them and the weakened and/or non-functioning antagonistic nerve and muscle groupings. By the application of intense will power and concentration in the mental rehearsal of this particular routine, it was considered a possibility that memory patterns of normal motions stored in some uninjured portion of the brain might be stimulated to direct impulses through non-functioning nerve channels of the incapacitated limbs, and that repetition might be utilized to strengthen said impulses to the partially paralyzed limb. There was also the thought that the attempt to transfer in the mind the "muscular feel" of eversion from the functioning left limb to the incapacitated right one might somehow facilitate this hypothetical possibility. If such could be accomplished, it was hypothesized that thousands of repetitions of this routine might possibly result in a progressive strengthening of these impulses to a point where, with the assistance of manipulative treatment, the incapacitated nerve and muscle groupings might be rehabilitated enough to overcome the nerve and muscular imbalance then in evidence. What the author did not know then, but has since discovered, was that he was operating largely on the basis of concepts associated with both the Motor Theory of Consciousness, and of Transfer of Training. At that time, however, the author's approach to the patient's problem was the result of personal experience with comparatively simple athletic training problems, a small amount of knowledge, and a large amount of intuition. No other logical explanation can be found to account for it.

A few weeks of heat treatments, massage, and manipulation of the incapacitated parts resulted in a decided increase in the flexibility of the right arm and hand, and the appearance of slight but new muscular reactions. The "mental practice" routine was employed with every session of manipulative treatment. At this time, it was decided to employ gravity with the manipulative exercises, reasoning that voluntary motion might be facilitated by so doing, and also that it might possibly serve as a psychological boost to the patient's morale.

Gravity was made use of by the simple expedient of placing the patient's hand at the top of a twelve-inch stick, held vertically on the bed by the therapist, to which was attached a light cord. This passed through a small pulley attached to a hospital bed table. At the end of this cord a small sling was tied in which tiny weights were placed at first, and then successively heavier ones as the patient improved. The subject was asked to grip the stick as best he could. The stick was pivoted on its base to one side by the therapist so as to lift the weight. At first, the patient was persuaded to apply mental effort only as outlined above, but after a few practice sessions he was then allowed to attempt to apply physical effort. In a surprisingly small number of sessions it became obvious that slight voluntary motion was developing. Progress in this respect was continued. It was not long before the patient, with the assistance of gravity, proceeded to lift increasingly heavier weights.

Up to this point it has not been mentioned that the patient's right leg was also partially paralyzed. A drop-foot condition was also involved. With apparent progress now being made with the right arm and hand, the same technique was now applied to his right leg. An improvement in mobility in this limb soon developed also.

Progress in developing voluntary motions in the incapacitated limbs was slow but steady. Resistive exercises were gradually introduced with the hope that they might facilitate the rehabilitation process. At first, many of these exercises turned out to be largely manipulative efforts on the part of the therapist, but there was interjected the psychological objective of stimulating the patient to believe that he would soon be competing against the therapist in a test of strength. The patient was again instructed to concentrate on the "mental practice" routine that had been used regularly up to this point. Progress with several motions was discouraging at first, and especially with the resistive approach to biceps flexion as a result of the biceps of the right arm being in an advanced stage of atrophy. However, by manipulating the patient's right arm to a fully flexed position, and continuing the resistive exercises, it was noticed that the muscles supplemental to the biceps during flexion of the arm were gaining strength. At the end of eleven months, these supplemental muscles had developed so much strength that the patient, by using a shoulder swing and hitch motion, could flip his right arm up to a point where the leverage of these supplemental muscles could make themselves felt, and the patient as a result could complete a flexion of the right arm with considerable force. In this way he learned to throw a softball very well. It was reported at the end of two years that the biceps resumed functioning.

To summarize, the progress of this patient was such that he was able to feed himself in six weeks, walk with a dragging step of the right leg in three months, and walk around the hospital compound with a surprising degree of facility by the end of eleven months.

All through this rehabilitation routine, the patient was asked to "mentally practice" his exercises between the regular sessions of therapy. Just how much he did this there is no way of knowing except that the patient gave strong assurance that he did so. The nurses often reported that they had observed him apparently concentrating on this "mental practice" routine. There is no reason to doubt the patient's affirmation that he did so.

The degree of this patient's recovery may be described as not only gratifying, but somewhat amazing. The questions that now came to be posed in the author's mind were: Just what were the actual factors in this patient's recovery? Was it a case that he would have recovered anyway as a result of the surgery performed on his shoulder? Was it a case of a patient with an unusual amount of will power that made the recovery possible? Was it a case of the massage and manipulative treatments being a highly contributory factor? Was the strong bond of friendship that grew between the patient and the author a strong psychological factor? Just what part, if any, did the "mental practice" routine play in the rehabilitation of the incapacitated limbs? The patient, and the attending neurosurgeon, agreed that the "mental practice" seemed to play some part, but as to just how, no answer was forthcoming. All that is known is that subsequent work with other similarly incapacitated patients produced results that were consistently better than would ordinarily be expected, and enough so that a strong feeling developed that this idea of mental practice, although quite largely an intuitive stab in the dark to start with, might have a great potential in physiotherapy.

After the author's discharge from the Navy and return to coaching activities, the idea occurred to him that perhaps mental practice, or mind rehearsal, of a motor skill might possibly be used in teaching motor skills related to athletics.

The dissertation at hand is the direct result of the experiences and ideas documented above. The idea that it might be possible to design research that would determine if "mental practice" had been a positive factor in the recovery of the patients in the physical rehabilitation program grew in intensity until it inspired the author to take positive action. It was reasoned that, if supporting evidence could be found, this technique might possibly be developed to a point where it could prove to be a boon in the field of physiotherapy, and also a means of lessening the amount of time that coaches and physical educators now find necessary to develop high efficiency in their charges in any particular motor skill.

After considerable thought, supplemented by several discussions with rehabilitation experts, it was decided that to start the research in mind with clinical cases of a nature similar to those mentioned in the above material was an impractical consideration. Instead, it seemed much more practical to investigate the hypothetical factor of mental practice through a medium which could be controlled under largely laboratory conditions, a basketball skill, for example. This was a provoking idea to a former basketball coach, and it led to the decision to employ the Pacific Coast one-hand foul shot as the medium of investigation.

The author wishes to acknowledge the persons who, through moral support, advice, and technical assistance, have contributed to this research effort.

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TABLE OF CONTENTS

PAGE

PREFACE ii

LIST OF TABLES xxiv

LIST OF FIGURES xxvi

CHAPTER

I. INTRODUCTION 1

Statement of the Problem 1

Definition of Terms 1

Purpose of the Study 2

Basic Assumptions 2

Hypotheses 5

Limitations 6

II. RELATED RESEARCH 9

The Effect of Mental Practice on the Development of Motor Skill 9

Conclusion 18

General Motor Ability 18

Conclusion 25

Arm Strength 25

Conclusion 28

Intelligence as a Factor in Motor Learning 29

Conclusion 31

Kinesthesis as a Factor in Motor Learning 32

Conclusion 38

The Role of Perception in Motor Learning 38

Conclusion 53

TABLE OF CONTENTS (Continued)

CHAPTER		PAGE
	The Time Factor in Motor Learning	54
	Conclusion	60
III.	THE DESIGN OF THE EXPERIMENT	61
	Basic Considerations	61
	Experimental Factors Emphasized	63
	Statistical Technique Selected	65
	Procedure of Administration	66
	Schools Selected	66
	Population Selected	68
	Measurement of Arm Strength	69
	Measurement of Intelligence	69
	Equating Subjects into the Factorial Grid	70
	Experimental Procedure	73
	Introspective Analysis	79
IV.	FINDINGS	83
	Treatment of Data	83
	Results of Treatment	87
	Results of Introspective Analysis	102
V.	SUMMARY	108
	Experimental Design	108
	Conclusions	110
	Implications for Further Study	112
APPENDIX A		123
I.	GROUP INTRODUCTION TO THE EXPERIMENT	123
II.	INTRODUCTION TO THE PACIFIC COAST ONE-HAND FOUL SHOT	124

TABLE OF CONTENTS (Continued)

APPENDIX A PAGE

III. INSTRUCTIONS FOR THE PACIFIC COAST ONE-HAND FOUL SHOT. 125

IV. INTRODUCTION TO THE "MENTAL PRACTICE" TECHNIQUE. . . . 130

V. "MENTAL PRACTICE" WORK SHEET 131

APPENDIX B 133

I. MASTER DATA SHEET FOR SCHOOL NO. I 134

MASTER DATA SHEET FOR SCHOOL NO. II. 135

MASTER DATA SHEET FOR SCHOOL NO. III 136

MASTER DATA SHEET FOR SCHOOL NO. IV. 137

II. DIAGRAM FOR EQUATING SUBJECTS ON THE BASIS OF ARM STRENGTH AND INTELLIGENCE

School No. I 138

School No. II 139

School No. III 140

School No. IV 141

III. DIAGRAM FOR EQUATING SUBJECTS ON THE BASIS OF ARM STRENGTH, INTELLIGENCE, PHYSICAL PRACTICE GROUP, MENTAL PRACTICE GROUP, CATEGORY OF EXPERIENCE

Varsity, School No. I 142

Varsity, School No. II 143

Varsity, School No. III 144

Varsity, School No. IV. 145

Junior Varsity, School No. I. 146

Junior Varsity, School No. II 147

Junior Varsity, School No. III. 148

Junior Varsity, School No. IV 149

APPENDIX B PAGE

Novice Group, School No. I. 150

Novice Group, School No. II 151

Novice Group, School No. III. 152

Novice Group, School No. IV 153

IV. PHYSICAL PRACTICE GROUP RECORD SHEETS

School No. I 154

School No. II 155

School No. III. 156

School No. IV 157

V. MENTAL PRACTICE GROUP RECORD SHEETS

School No. I. 158

School No. II 159

School No. III 160

School No. IV 161

VI. VALUES REQUIRED FOR OBTAINING THE SUMS OF SQUARES AND PRODUCTS 162

VII. VALUES REQUIRED FOR OBTAINING THE SUMS OF SQUARES AND PRODUCTS SPECIFIED IN TABLE XXII 167

VIII. AN ILLUSTRATION OF HOW THE SUMS OF SQUARES AND PRODUCTS WERE OBTAINED 177

IX. SCORES, SQUARES, AND CROSS PRODUCTS FOR ALL ARM STRENGTH X INTELLIGENCE X GROUP COMBINATIONS 178

X. NOTES TAKEN ON THE INTROSPECTIVE ANALYSES. 179

APPENDIX C (SUPPLEMENTARY STUDIES). 188

I. A GRAPH OF THE EFFECT OF VERBAL INSTRUCTION ON THE LEARNING CURVES OF TWO GROUPS AS BASED ON THE CUMULATIVE ARITHMETIC MEANS OF HIGH AND LOW SCORES IN SHOOTING FOUL SHOTS 189

TABLE OF CONTENTS (Continued)

APPENDIX C		PAGE
II.	MASTER DATA SHEET FOR SCHOOL NO. V.	190
III.	DIAGRAM FOR EQUATING SUBJECTS (SCHOOL NO. V) ON THE BASIS OF ARM STRENGTH AND INTELLIGENCE	191
IV.	DIAGRAM FOR EQUATING SUBJECTS (SCHOOL NO. V) ON THE BASIS OF ARM STRENGTH, INTELLIGENCE, PHYSICAL PRACTICE GROUP, MENTAL PRACTICE GROUP, CATEGORY OF EXPERIENCE	192
	Varsity, School No. V.	192
	Junior Varsity, School No. V.	193
	Novice Group, School No. V	194
V.	PHYSICAL PRACTICE GROUP RECORD SHEET FOR SCHOOL NO. V	195
VI.	MENTAL PRACTICE GROUP RECORD SHEET FOR SCHOOL NO. V.	196
VII.	FINDINGS OF THE SPECIAL PHASE OF THE EXPERIMENT . . .	197
VIII.	TIME PATTERNS SUGGESTED AS A BASIS FOR DETERMINING THE EFFECTS OF PHYSICAL PRACTICE, MENTAL PRACTICE, AND INTERPOLATED TIME.	201
BIBLIOGRAPHY		202
AUTOBIOGRAPHICAL STATEMENT		209

LIST OF TABLES

Table		Page
I.	Factorial Grid of the Four Schools Participating in the Experiment	84
II.	Tests of Significance of the Interactions	88
III.	Improvement of the Physical Practice Groups of the Four Schools in Terms of Baskets and Per Cents	94
IV.	Improvement of the Mental Practice Groups of the Four Schools in Terms of Baskets and Per Cents	94
V.	Comparison of the Totals of the Arm Strength Scores of the Four Schools	98
VI.	Comparison of the Totals of the Initial Scores of the Four Schools as Based on 300 Shot Attempts by Each Experience Category.	98
VII.	Comparison of the Totals of the Intelligence Quotients of the Physical Practice Groups of the Four Schools	100
VIII.	Comparison of the Totals of the Intelligence Quotients of the Mental Practice Groups of the Four Schools	100
IX.	Average Number of Minutes of Mental Practice Per Subject Per Day for Each of the Four Schools.	101
X.	Master Data Sheet for School No. I.	134
XI.	Master Data Sheet for School No. II	135
XII.	Master Data Sheet for School No. III.	136
XIII.	Master Data Sheet for School No. IV	137
XIV.	Physical Practice Group Record Sheet for School No. I	154
XV.	Physical Practice Group Record Sheet for School No. II	155
XVI.	Physical Practice Group Record Sheet for School No. III.	156

LIST OF TABLES (Continued)

Table		Page
XVII.	Physical Practice Group Record Sheet for School No. IV	157
XVIII.	Mental Practice Group Record Sheet for School No. I.	158
XIX.	Mental Practice Group Record Sheet for School No. II	159
XX.	Mental Practice Group Record Sheet for School No. III.	160
XXI.	Mental Practice Group Record Sheet for School No. IV	161
XXII.	Values Required for Obtaining the Sums of Squares of Products.	162
XXIII.	Values Required for Obtaining the Sums of Squares and Products Specified in Table XXII.	167
XXIV.	Scores, Squares and Cross Products for all Arm Strength x Intelligence x Group Combinations.	178
XXV.	Master Data Sheet for School No. V	190
XXVI.	Physical Practice Group Record Sheet for School No. V.	195
XXVII.	Mental Practice Group Record Sheet for School No. V.	196
XXVIII.	The Total of the Initial Scores of the Three Experience Categories (School No. V) as Based on 300 Shot Attempts by Each Category	197
XXIX.	Improvement of the Physical Practice Groups (School No. V) in Terms of Baskets and Per Cents.	198
XXX.	Improvement of the Mental Practice Groups (School No. V) in Terms of Baskets and Per Cents.	199
XXXI.	Time Patterns Suggested as a Basis for Determining the Effects of Physical Practice, Mental Practice, Interpolated Time	201

LIST OF TABLES (Continued)

Table		Page
XXXII.	Number of Baskets Gained for Subjects With Initial Scores of 13 or Below, and 14 or above	201b
XXXIII.	Adjusted Final Means, $\bar{Y}_a$, For Mental and Physical Practice Groups Within Schools and Classes	201c
XXXIV.	Tabular Presentation of Initial Score Means, Final Score Means, and Gains of Mental and Physical Practice Groups	201e
XXXV.	Tabular Presentation of Adjusted Final Score Means of Mental and Physical Practice Groups. . .	201f

LIST OF FIGURES

Figure Page

Diagram for Equating Subjects on the Basis of Intelligence and Arm Strength

1. School No. I 138
2. School No. II 139
3. School No. III 140
4. School No. IV. 141

Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience

5. Varsity, School No. I. 142
6. Varsity, School No. II 143
7. Varsity, School No. III 144
8. Varsity, School No. IV 145
9. Junior Varsity, School No. I 146
10. Junior Varsity, School No. II. 147
11. Junior Varsity, School No. III 148
12. Junior Varsity, School No. IV. 149
13. Novice Group, School No. I 150
14. Novice Group, School No. II. 151
15. Novice Group, School No. III 152
16. Novice Group, School No. IV. 153
17. A Graph of the Effect of Verbal Instruction on the Learning Curves of Two Groups as Based on the Cumulative Arithmetic Means of High and Low Scores in Shooting Foul Shots 189
18. Diagram for Equating Subjects (School No. V) on the Basis of Arm Strength and Intelligence. 191

Figure Page

19. Diagram for Equating Subjects (Varsity Group, School No. V) on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience 192

20. Diagram for Equating Subjects (Junior Varsity Group, School No. V) on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience 193

21. Diagram for Equating Subjects (Novice Group, School No. V) on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience 194

CHAPTER I

INTRODUCTION

Statement of the Problem

To determine if "Mental Practice," when substituted for physical practice in the development of a certain motor skill, the Pacific Coast one-hand foul shot, will result in an improvement in that skill.

Definition of Terms

Mental Practice. For the purpose of this experiment, practice in visualizing the specific positions of body and limb, and the sequence of same, as they relate to the motor skill being used as a medium of investigation.[1]

Novice. For the purpose of this experiment, a subject who has not had the advantage of organized coaching and playing experience in the motor skill being used as a medium of investigation; one inexperienced in said skill.

Kinesthesis. The sense which enables a person to determine the position of segments of the body, their rate, extent, and direction of movement, the position of the entire body, and the characteristics of total body motion.[2]

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[1]See Appendix A, "Mental Practice Work Sheet.

[2]Gladys M. Scott, "Kinesthesis," Res. Quart., 26: pp. 324-341, o'55.

Knowing. For the purpose of this experiment, knowing exactly the sequence of positions and motions that constitute the mechanics of the motor skill under consideration, and the reasons why said positions and motions provide the greatest potential for success.

Seeing. For the purpose of this experiment, looking at one's self as best as possible while carefully posing through the sequence of positions that constitute the total mechanics of the skill being practiced.

Feeling. For the purpose of this experiment, concentration on the kinesthetic or motor sense while posing through the sequence of positions, and also during execution of the motions of the skill being practiced at a normal functional speed.

Purpose of the Study

To compare the effect of mental practice with that of physical practice in the development of a motor skill in a search for findings that may be utilized by coaches and physical educators to improve their instructional skill.

Basic Assumptions

1. It is assumed that perceptual ability varies from person to person within a considerable range.

2. It is assumed that the ability to visualize specific positions and motions involved in the total sequence that constitutes the body mechanics of a complex motor skill may well be a major determinant of the degree of success any individual will have in an attempt to master that skill.

3. It is assumed that the visualization of the specific positions and motions that constitute the mechanics of a complex motor skill may best be achieved by combining the psychological processes of knowing and seeing with the psycho-physical process of feeling, said processes being considered in the light of definitions previously indicated.[1]

4. Inasmuch as the factors influencing the development of any particular motor skill may vary from fifty to one hundred, it is considered impractical to attempt to equate for all of them. It is assumed, as a result of an extensive search of literature, that said factors will individually exert only a small influence on the experiment with the exception of arm strength, schools, classes, measures, and groups. Inasmuch as not much is known about the effect of mental practice in the development of motor skills, it is considered important to equate the subjects for the factor of intelligence because of the possibility that intelligence, as measured by standard tests such as the one used in this experiment, may be found to correlate more positively with motor skill in the case of mental practice than was heretofore found in the case of physical practice.

5. On the basis of the evidence examined, it is assumed that the factors of knowing, seeing, and feeling, as previously defined, may well be major factors in the development of the Pacific Coast one-hand foul shot through mental practice when their effects are combined in the experimental technique.

6. It is assumed that mental practice, as conceived for this

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[1] See page 2.

particular research project, will result in an increase of the subject's skill in utilizing native perceptual ability.[1]

7. As it is considered almost impossible to obtain subjects for the experiment who have not had at least some experience in basketball, if only of a vicarious nature, and as it also seems impossible to determine the exact amount and quality of experience each subject has had, it is assumed that a selection of subjects for the experiment on the basis of high school varsity participation, high school junior varsity participation, and high school novice participation should result in three reasonably distinct categories for the experience factor.

8. It is assumed that the category with the least experience in basketball stands to improve the most, all other factors being nearly equal.

9. Inasmuch as it was considered impractical to attempt to equate for the factors of knowing, seeing, and feeling,[2] it is assumed that introspective analysis by the subjects at the termination of the experiment may provide clues as to the effect of said factors. on the perceptual processes as they relate to the mental practice technique employed.

10. It is assumed that excellent rapport between the investigator and the subjects participating in the experiment with a resulting high morale throughout the course of the experiment is a must if mental practice is to be given a fair trial. It is expected that the morale should be generally high due to the fact that the

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[1]See Appendix A, "Mental Practice" Work Sheet.

[2]See definitions, page 2.

varsity and junior varsity subjects, at least, have a large emotional investment in the game of basketball, or they would not spend the time and energy they do in practice. It is also assumed that high morale in the novice category may be partially assured by selecting subjects from a considerable number of volunteers for the experiment who are desirous of becoming good basketball players.

11. It is assumed that there may be a range of approximately four years of age between the youngest and the oldest subjects to be found in the three experience categories. From the past experience of the author, it is expected that the average age of the varsity and junior varsity will disclose only a small disparity. The problem appears to be one of selecting the novices in a way that the average age of that group is not too much different from the other two. It is to be pointed out, however, that twenty years experience with high school basketball players has disclosed to the author that freshmen and sophomore players are frequently stronger than the upper classmen. With the exception of experience, age as a factor for the three categories named is often of no great importance. It is assumed that there is likely to be only a small correlation between arm strength and age in these three special categories.

Hypotheses

1. Mental practice has a positive effect on the development of a certain motor skill, the Pacific Coast one-hand foul shot.

2. There is little or no relation between the intelligence quotient for each subject as measured by the Short Form of the

California Mental Maturity Test, and the degree of improvement on the Pacific Coast one-hand foul shot resulting from mental practice.

3. There is a positive relationship between arm strength, as measured by the Roger's Formula, and the degree of skill achieved by the subjects in this experiment.[1]

Limitations

1. To select subjects on the basis of varsity, junior varsity, and novice experience was to limit the number available from any one school inasmuch as the members of a varsity high school basketball team rarely number more than twelve. Since equal numbers were used in each category, this, therefore, restricted the number to approximately twelve in both the junior varsity and novice groups. With the subjects limited within one school, it was therefore necessary to replicate the experiment in several schools in order to gain sufficient numbers to provide adequate data.

2. Since the varsity, junior varsity, and novice categories of twelve subjects each were divided into a mental practice group and a physical practice group, and these were equated by the paired groups technique into a factorial design on the basis of high, average, and low arm strength, and high and low intelligence, a small amount of <u>forcing</u>[2] was necessary within the rank-order distribution. An

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[1] Frederick Rand Rogers, <u>Physical Capacity Tests in the Administration of Physical Education</u>. (New York: Bureau of Publications, Teachers College, Columbia, 1926).

[2] See definition, page 72.

attempt was made to do the forcing in the intelligence quotient column so as to disturb as little as possible any influence the factor of arm strength might have on the factorial design.

3. As it was necessary to implant the experimental procedure into regular physical education programs, it was expected that there would be a certain amount of disturbance of the subjects involved in the experiment as a result of other activities occurring in the gymnasia at the same time.

4. As there was no objective method available for measuring the quality of the morale of the subjects during the course of the experiment, it was necessary to rely on the subjective judgments of the various subjects and their coach for determining the effect of this factor. It was realized that monotony might develop during the mental practice sessions near the latter part of the experiment that could well affect the final results.

5. Only a small number of factors, but apparently highly important ones with the exception of intelligence, were equated for. It was recognized that other factors would possibly affect the results in some small degree. The conviction was held, however, that the experimental design was a sound one for investigating the effect of mental practice in the development of motor skill. It was felt that careful execution of the experimental procedure accompanied by careful observation and with an open mind as to any unexpected effects from unequated variables, plus the utilization of introspective analysis by each subject at the termination of the experiment might prove in part to be a compensating factor by at least providing leads for

further and more conclusive experimentation.

6. The number of practice shots, 25, and the number of trial shots, 25, taken to obtain an Initial Score for each of the participating subjects were arbitrary numbers selected primarily in consideration of the limited time available for the execution of the experimental procedure. It had been suggested by a few critics of the experiment that a more valid initial score might have been obtained by having the subjects take trial shots for approximately three days, and then take the average of the number of shots made as the initial score. However, the author considers it important to point out that the varsity, and junior varsity subjects had just completed a full season of basketball, and that most of the novices had no doubt been indulging in at least a reasonable amount of free play with a basketball. There is also this consideration: Any coach who has observed his players shooting baskets informally just a few days after the end of the season has no doubt noticed that most of them shoot much more accurately than they did during the last days of the playing season, probably because fatigue and psychological pressures have been eliminated. This consideration, plus the possibility that the stimulation resulting from what could well be an exciting piece of research in the minds of the subjects, was expected to result in higher initial scores than a three-day average from shooting foul shots under normal conditions would produce.

CHAPTER II

RELATED RESEARCH

Just how many factors, and in what proportion, influence the development of any particular motor skill is not known. The number has been variously estimated by investigators as anywhere from fifty to a hundred. Believing that it is technically impossible to equate for all known factors influencing any motor skill, the author decided to do a search of literature concerning factors he considered merited special consideration before any final decision for an experimental design for this particular problem could properly be made. The factors investigated were as follows: 1. Mental Practice; 2. General Motor Ability; 3. Strength; 4. Intelligence; 5. Kinesthesis; 6. Perception; 7. Time.

The Effect of Mental Practice on the Development of Motor Skill

An extensive examination of literature disclosed only a few pieces of research that were designed primarily to investigate the effect of mental practice on the learning of a motor skill. Wilbur E. Twining has made an observation which is very pertinent to the one above:

> In spite of the rapid advancement in the scientific approach to physical education, there is little in the literature to indicate just how much motor learning is physical and how much mental. There is little doubt that knowledge of mental activity required for efficient motor learning would aid physical educators in an

understanding of teaching techniques. But the variable of mental activity is one which is difficult to isolate and measure. At best it can only be roughly compared to its given counterpart in physical activity. The very sparseness of references to this concept in the literature serves all the more to emphasize the importance of this gap in our knowledge.[1]

Twining conducted a study to investigate the effect of mental practice in the learning of a motor skill. He had a group of 36 college men, selected at random, practice ring-tosses under one of three conditions:

Condition 1. 12 subjects threw 210 rings on the first and twenty-second days of the experiment.

Condition 2. 12 subjects threw 210 rings on the first day, 70 rings each day from the second through the twenty-first day, and 210 rings on the twenty-second day.

Condition 3. 12 subjects threw 210 rings on the first day, mentally rehearsing their first day's activity for fifteen minutes daily from the second through the twenty-first day.

The subjects under Condition 3 were instructed to rehearse mentally their initial test, trying to visualize all the sensations that they went through. They were cautioned to perform no overt movements, but to actually "mentally throw" rope rings at imaginary targets.

Results: Improvement was measured by the difference in scores between the first practice day and the twenty-second practice day.

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[1] Wilbur E. Twining, "Mental Practice and Physical Practice in Learning a Motor Skill," Research Quarterly (Berkeley, California: University of California, January, 1949).

The 12 subjects under Condition 1 improved 4.3%. The 12 subjects under Condition 2 improved 137.3%, and the 12 subjects under Condition 3 (mental practice) improved 36.2%.

It would appear from the results of this experiment that mental as well as physical practice facilitates the learning of motor skills.

The amount of practice under the conditions set up for this experiment was not equated as to the time factor. The mental practice periods were for fifteen minutes daily while physical practice involved tossing 70 rings at whatever rate the subjects desired. The time required to toss 70 rings was reported as ranging from five to ten minutes with an average of about seven-and-one-half minutes, or only half of the time spent by the mental practice group. Twining reported that introspective comments recorded by the subjects during mental practice indicate that genuine mental effort was effective for only about the first five minutes of each practice period.[1] Beyond this, concentration became increasingly difficult.

The mental practice period was reported by the subjects as usually being spent in "mentally picturing" the entire ring-tossing procedure. Occasionally subjects were said to have reported attempts at working out "new theories" of tossing with the hope of improving performance. Several such theories were reported as unsuccessful during the final test, forcing the subjects to revert to their original style.

The subjects were not equated as to ability to learn gross bodily skills nor as to general motor ability.

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[1] Ibid.

Doubt is expressed by the author that 12 subjects for each of the three conditions of the experiment were a sufficient number to provide data on which any strong conclusions could be based. The procedure and findings are, however, such as to provoke interest in further research of a similar kind.

Vandell, Davis and Clugston, employing 12 senior high school boys to practice standard basketball foul throws under one of three conditions, and 12 junior high school, and also 12 college freshmen subjects practicing with darts, investigated the function of mental practice in the acquisition of motor skills.[1]

A group of 12 senior high school boys practiced 35 standard basketball foul shots under one of three conditions:

Condition 1.	4 boys on 1st and 20th days.	Improvement 2%.
Condition 2.	4 boys on each of 20 days.	Improvement 41%.
Condition 3.	4 boys on 1st and 20th days with 15 minutes of mental practice from 2nd through the 19th day.	Improvement 43%.

The authors concluded that mental practice was about as effective as physical practice under the conditions of this experiment.

Selection of subjects and the equating of groups were reported as being realized by a series of standardized tests which included intelligence, educational age, chronological age, motor ability, eyes, and physique as based on measures of height, weight, growth.

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[1]Roland A. Vandell, R. A. Davis, and H. A. Clugston, "Function of Mental Practice in the Acquisition of Motor Skills," Journal of Gen. Psychol., 29 (October, 1943), pp. 243-250.

The objective underlying the diversified testing program was to choose subjects approaching normality on all equating factors, and to eliminate those who deviated noticeably from the so-called "average" in any one of the equating factors.

The author hereby questions if it is a thoroughly sound consideration to equate only for the "average" subject. Certainly, under normal conditions, the physical educator has to deal with a wide range of native abilities. A strong conviction is held that the deviates from the so-called "average" must somehow be included in such experimentation if a true picture is to be obtained of the cause and effects as they relate to "mental practice."

The authors of the above experiment reported that an attempt was made to win the confidence of their subjects and to encourage maximum cooperation without divulging the true nature of the work undertaken.

The group of 12 junior high school boys practiced throwing darts under one of three conditions:

Condition 1.	4 boys on 1st and 20th days.	Improvement 2%.
Condition 2.	4 boys on each of 20 days.	Improvement 7%.
Condition 3.	4 boys on 1st and 20th days with 30 minutes of mental practice (one minute break at half-way mark for rest) 2nd through the 19th day.	Improvement 4%.

Procedure: 25 darts thrown and the cumulative arithmetic mean taken. All 12 subjects were tested separately in this manner.

On the 20th day, all three groups were called for a final physical practice trial similar to that taken on the first day.

The dart target used consisted of 17 regular concentric circles with a bull's eye having a radius of one inch, each succeeding circle increasing in radius by one inch. Each zone or circle was assigned a numerical value, beginning with a center value of 17 and successively diminishing in assigned values by one until the outermost circle had a value of one.

An important sidelight to the experiment was the fact that one of the mental practice group showed a loss. In an attempt to discover the reason, the authors gave each of the four the Mental Imagery section of the Binet Test (reversing the hands of the clock). The boy showing the loss failed this test completely whereas the other three passed it satisfactorily.

The group of 12 college freshmen boys were instructed to practice throwing darts under the same conditions as the junior high school boys, with the exception that mental practice was cut down to fifteen minutes a day:

Condition 1.	4 boys on 1st and 20th days.	Improvement 0 %.
Condition 2.	4 boys on each of 20 days.	Improvement 23%.
Condition 3.	4 boys on 1st and 20th days with 15 minutes of mental practice from 2nd through the 19th days.	Improvement 22%.

Vandell, Davis, and Clugston concluded that the significance of the mental practice element was demonstrated sufficiently by these experiments to be suggestive of future research in the same fields, and that these findings might have important implications in the field of education if substantiated by future research.[1]

Certainly, it must be observed that the number of subjects employed in these experiments by Vandell, Davis, and Clugston is insufficient to produce data on which one might base any strong conclusions.

Ella Trussell investigated mental practice as a factor in the learning of a complex skill.[2] She employed college women as subjects for an experiment in learning to juggle three tennis balls. Five experimental groups were equated on the results of fifty trials taken in one day. Group 1 was given 20 trials daily for 15 days, then a 50-trial retest. Group 2 practiced "mentally" 5 minutes daily for 5 days, had 20 trials daily for 10 days, then a 50-trial retest. Group 3 practiced "mentally" 10 days, had 20 daily trials for 5 days, a final 50-trial retest. Group 4 practiced "mentally" for 15 days, then was retested. Group 5 was asked to forget the experiment until the final retest.

Results show: (a) No significant effect; (b) some reminiscence in all groups for which a period of one to three weeks occurred between the first and second physical trials; (c) one week of "mental practice" followed by two weeks of physical practice is as effective as three weeks of physical practice; (d) additional "mental practice" is of no value.

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[1] Ibid.

[2] Ella May Trussell, Mental Practice as a Factor in the Learning of a Complex Motor Skill. (Berkeley, California: University of California).

Perry investigated the relative efficiency of actual and imaginary practice on five selected motor tasks ranging from those demanding simple coordination to those requiring ideational processes.[1] Both types of practice were found to be effective with the imaginary practice having its maximum effectiveness for those tasks involving ideational activity.

Harby investigated the problem of "mental" versus "physical" practice in learning to net a basketball.[2] Two hundred and fifty subjects were employed for various periods of time. Mental practice was obtained by watching a moving picture which demonstrated the movement to be learned. The results show that: (a) A physical skill can be learned by mental practice; (b) the effectiveness of mental practice varies with the length of the practice and the subjects; and (c) mental and physical practice combined are probably more effective than either kind alone. No doubt there are persons who will argue that viewing an instructional film is not true mental practice. It seems logical, however, to consider viewing an instructional film as mental practice if the viewing is accompanied by intent to learn the skill being depicted.

John C. Flanagan, in discussing a study by the Army Air Forces Psychological Test Film Unit, points out that an incidental finding

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[1] H. M. Perry, "The Relative Efficiency of Actual and Imaginary Practice in Five Selected Tasks," Arch. Psychol., No. 243 (New York: 1939).

[2] S. F. Harby, Comparison of Mental and Physical Practice in the Learning of Physical Skill (Pennsylvania State College). U.S.N., Spec. Dev. Cent. Tech. Rep., SDC 269-7-27, 1952. Page 11.

was the apparent value of utilizing the subjective point of view in the filming of motion pictures.[1] By moving the camera back to the position where the situation was viewed from the viewpoint of the trainee in the learning situation, the student viewing the film could easily imagine himself in the actual activity rather than outside it as an onlooker. By showing the situation from the position in which only the hands of the character and his manipulations are visible and pacing the film slowly, it was possible to provide the student with a large amount of "mental practice" which could be immediately reinforced or corrected.

G. Rubin-Rabson, in a study of mental and keyboard overlearning in memorizing piano music, found that no benefit comes from prolonging work on analysis and organization of the material preliminary to keyboard practice, even to the point of memorizing an 8-measure period.[2] He has pointed out that the intensive mental rehearsal of the material at some point before completion of the learning trials not only saves keyboard trials, but is as effective for retention as a greater number of keyboard trials followed by keyboard overlearning equivalent to the mid-way study.

Shaw, in an investigation of the relation of muscular action potentials to imagined weight lifting, employed apparatus consisting of an amplifier and oscillator, a cathode-ray oscillator, a camera,

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[1]Army Air Forces Aviation Psychology Program Research Reports, Report No. 1, Edited by John C. Flanagan, Professor of Psychology, University of Pittsburgh, 1948, pp. 254-55.

[2]G. Rubin-Rabson, "Mental and Keyboard Overlearning in Memorizing Piano Music," J. Musical (1941), pp. 3, 33-40.

and weights.[1] Three male subjects were used. A series of weights were placed behind a screen. At no time were the subjects allowed to see the weights. Electrodes were attached to the subject's right forearm and he was instructed to relax. Weights were presented for 100, 150, 175 trials. The subject was also instructed to imagine lifting the weights which he was familiar with only by touch. Action potentials during imaginal lifting disclosed that implicit muscular activity occurred. During imagining as well as during actual lifting, it was reported that this activity increases linearly with the magnitude of the weight.

Conclusion

The above studies, although limited in number, provide sufficient evidence that "mental practice," or mind rehearsal, of motor skill may produce enough improvement to warrant a further and more intensive investigation of its potential effect.

General Motor Ability

A question of major importance to those engaged in research in physical education has long been as to whether or not there is a general factor underlying athletic ability. Jones was unable to find a general factor underlying athletic ability in general, and concluded that each sport must have its own pattern of requisite

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[1] W. A. Shaw, "The Relation of Muscular Action Potentials to Imagined Weight Lifting," Arch. Psychol., (New York: 1940), No. 247, p. 50.

abilities.[1]

Seashore, as a result of his investigation of some relationships of fine and gross motor abilities, concluded that statistically, in terms of factorial analysis, there is weak or no evidence for a general motor factor.[2]

Seashore, Buxton and McCullum, as a result of their multiple factorial analysis of fine motor skills, have this to say:

> We need not deny the existence of individual differences in biological factors, such as speed of muscle contraction, but as might be inferred from the study of Bryan and Harter on higher units in telegraphy,[3] and the similar studies by Book on typing,[4] any one physiological limit is usually important only for a given work method, and changing to another work method may either partially or entirely overcome its limitation. Further factor analysis will need perhaps more to be supplemented by qualitative techniques, such as motion study of these methods, than by improvement of statistical techniques.[5]

McGraw, in a factor analysis of motor learning, used variables obtained from the results of a research project conducted by Brace,[6]

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[1]Lloyd M. Jones, _A Factorial Analysis of Ability in Fundamental Motor Skills_ (Contributions to Ed., No. 665, New York Bureau of Publications, Teachers College, Columbia University, 1935).

[2]H. G. Seashore, "Some Relationships of Fine and Gross Motor Abilities," _Research Quart._, 13 (1942), pp. 259-74.

[3]W. L. Bryan, and Noble Harter, "Studies in the Telegraphic Language: The Acquisition of a Hierarchy of Habits," _Psychol. Rev._ (1899), No. 6, pp. 374-85.

[4]W. F. Book, _Learning to Typewrite_ (1925), pp. 120-22.

[5]R. H. Seashore, C. E. Buxton, and L. N. McCullum, "Multiple Factorial Analysis of Fine Motor Skills," _Amer. J. Psychol._, 53 (1940), pp. 251-59.

[6]David K. Brace, "Studies in Motor Learning of Gross Bodily Skills," _Research Quarterly_, 17:4 (December, 1946), pp. 242-53.

and came to the following conclusions:

1. In general, the tests commonly accepted as measures of motor ability, athletic ability, speed, agility, power, strength, and throwing for distance, are not influenced by the factors of motor learning. In most instances, each factor accounts for less than four per cent of the variance in each test, and the largest percentage accounted for by any factor in any one test is 22 per cent.
2. It seems that none of the tests of physical ability could be used to measure the factors of motor learning identified in this study. Likewise, none of the tests of motor learning could be used to predict success in the tests of physical ability.
3. It appears that these factors of motor learning, if they are factors, are distinct ones. <u>A distinct factor may be involved only in a specific part of the performance of an activity</u>. For example, aiming control may be a specified part of the sport activity of pitching, or throwing to a baseman. It seems possible that many factors exist, and that success in a sport or even a separate activity in a sport would depend on a certain combination of several factors rather than one factor alone.[1]

These conclusions certainly suggest that there is yet much to be learned about the factors inherent in the many kinds of athletic

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[1] L. W. McCraw, "A Factor Analysis of Motor Learning," <u>Research Quarterly</u>, Vol. 20 (1949).

motor activity.

Harrison Clarke has this to say:

> A test of all-round athletic ability does not measure skill in any particular sport. An individual with a high score on such a test, however, should perform well, or have capacity of good performance after a period of instruction, in a number of athletic events . . . actually, general motor ability is complex. Many factors enter into efficient motor performance: physical, mental, emotional, and social. It is a gestalt, with the whole personality dynamically organized, that results in excellent performance. Physically, motor efficiency or skill is composed of strength, endurance, speed, and the coordination or control of these elements for accuracy.[1]

Fleishman makes the point that there are definite problems and limitations which one encounters in comparing factor analysis studies. He says:

> A major difficulty is the different interpretations given to factors by different researchers. This is sometimes only a case of semantics, but in at least a few cases two investigators might give entirely different meaning to factors. Also, the interpretations given factors are often based on too limited evidence.[2]

He also points out that there is difficulty comparing factors derived by different factor methods, and in addition, there is the lack of identity of tests in the different batteries factor analyzed. As a consequence, factors based on different sets of tests may be given the same nomenclature, but that they are operationally the same is yet to be demonstrated. Another problem he points out is that of sampling errors. "No satisfactory measure of the standard error of a

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[1]Harrison H. Clarke, Application of Measurement to Health and Physical Education (New York: Prentice-Hall, Inc.), p. 253.

[2]Edwin A. Fleishman, Testing for Psychomotor Abilities by Means of Apparatus Tests (U. S. A. F. Training Command Human Resources Research Center, Psychological Bulletin Vol. 50, No. 4, July, 1953), p. 241.

factor loading has been determined. Thus small loadings may not indicate that the test is measuring a given factor. However, if these small loadings repeatedly show up on replications of the factor analysis, one might have considerable confidence in their significance."[1] Fleishman contends that factor studies, as well as experimental ones, indicate that success in complex motor activities may depend upon non-motor as well as motor factors, as for example: Spatial relations, mechanical experience, and perceptual speed. He suggests that much additional research is needed to clarify a dimensional analysis of motor abilities. It is his viewpoint that the major emphasis in future research in this aptitude area should be given to systematic investigation of basic psychomotor dimensions.

Tiffin has indicated that the tradesman usually succeeds or fails in proportion to his training and general mechanical comprehension, not in proportion to his basic dexterity.[2] The point is made that this does not mean that successful tradesmen do not need skilled movements, but rather that such muscular coordination as may be needed can be developed in training, and it is a lack of some other ability (*e.g.*, mechanical comprehension) rather than inability to develop muscular aspects of the job, that may prevent proficiencies in the job. Similarly, Harrell feels that success in such jobs as textile-working involves more the ability to visualize certain aspects of the job and only a negligible extent to muscular dexterity.[3]

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[1] *Ibid.*

[2] J. Tiffin, *Industrial Psychology* (New York: Prentice-Hall, Inc., 1947).

[3] T. W. Harrell, "Testing the Abilities of Textile Workers," *St. Engng. Stat. Bull.*, No. 2 (Georgia, 1940), p. 2.

Fleishman suggests that there have been too few studies on the final level of motor skill attainment to evaluate these hypotheses properly, adding that it appears that a basic need in this area is an extensive dimensional analysis of motor abilities which would reveal a more basic classification of factors primarily important in performance of a wide variety of psychomotor tasks.[1] Fleishman reports in another study that in psychomotor tests the influence of abilities tested may shift in importance, so one should know when fluctuations occur, at what point the test is most complex, and when it measures only one variable.[2] He suggests that the answers be provided by factorial methods.

McCloy suggests an analysis of motor educability paralleling the study of intelligence pointing out that numerous factors have been tentatively identified by such methods as factor analysis.[3] He lists the following ten factors as prerequisites to effective learning of motor skills: Muscular strength, dynamic energy, ability to change direction, flexibility, agility, peripheral vision, good vision, concentration, understanding of the mechanics of the techniques of the activities, and absence of disturbing or inhibiting emotional complications. Other factors in motor educability he summarizes as: Insight into the nature of the skill; ability to visualize spatial

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[1]Fleishman, op. cit.

[2]Edwin A. Fleishman, "A Factor Analysis of Intra-Task Performance on Two Psychomotor Tests," Psychometrika, 28:2161 (1952), pp. 18, 45-55.

[3]C. H. McCloy, "A Preliminary Study of Factors in Motor Educability," Research Quarterly, Vol. II, No. 2 (May, 1940), p. 28.

relations; ability to make quick, adaptive movements and adaptive decisions; sensory-motor coordination relation of eye to hand or foot; sensory-motor coordination related to weight and force; judgment of the relationship of the subject to external objects in relation to time, height, distance, and direction; general kinesthetic movements that follow one another in rapid succession; arm control; factors involved in the function of balance; timing; motor rhythm; sensory rhythm; and esthetic feeling.

Campbell disagrees with the results of other investigators as to the presence or absence of a general motor ability, and in so doing he makes a point that seems to be well worth careful investigation.[1] In an earlier study he had demonstrated the presence of an apparent general ability across four serial performances. Other investigators have obtained low correlations between motor tasks and have therefore denied the existence of a general motor ability as the above studies have indicated. In this study, Campbell repeated the previous experiments and introduced several controls for the purpose of determining to what extent the general ability found was due to the use of a particular organ. According to his analysis of the evidence, the absence of general motor ability is due not so much to the simple differences between performances in sense organ used as to the large difference apparent in the cognitive processes of discrimination necessary for the performance.

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[1]M. Campbell, "The Cognitive Aspects of Motor Performances and Their Bearing on General Motor Ability," J. Exp. Psychol., 19 (1939), pp. 323-33.

Conclusion

The results of factorial analysis suggest that each sport skill may well have its own particular gestalt of variables thereby posing the question: How are we to determine the particular gestalts of ability required for each sport skill? Without a knowledge of these gestalts, how can we get a reasonable research control over experimentation in the teaching of any particular sport activity? It appears that extensive research will be necessary before these questions can be properly answered. The above information indicates that there is no need for a consideration of the hypothetical factor of general motor ability in the design of this particular experiment.

Arm Strength

Inasmuch as the Pacific Coast one-hand foul shot has been selected as the medium for research on the effect of substituting mental practice for physical practice in the development of motor skill, the potential effect of arm strength has been examined due to the fact that this particular shooting technique is mechanically largely a one-armed and one-handed shot with only a slight amount of body action contributing to the effectiveness of said shot.

McCloy, as a result of an investigation of the apparent importance of arm strength in athletics, has this to say:

> In a relatively large proportion of the high school population of the boys, the back and legs are probably fairly well developed to the standard of the weight of the body. Every boy has to carry himself around and if he engages in the usual athletic program his legs and trunk will inevitably develop to the point of being able to carry his body weight

> effectively . . . In case the arms are well developed as to strength, the back and legs are usually also well developed. The individual develops his arms doing activities which use the other muscle groups. The reverse, however, is not necessarily true; for individuals who engage in running or jumping programs develop the trunk and legs, but do not necessarily develop the arms. The correlation between chinning strength alone and all the rest of the body in which the comparison was made was .91.[1]

Hinton and Rarick did a study of the correlation of Roger's Test of Physical Capacity and the Cubberly and Cozens Measurements of Achievement in Basketball utilizing 64 college women.[2] They obtained a correlation of .55 between the Cubberly and Cozens Basketball Test and arm strength, which was the highest correlation between the test and any of the strength variables. Contrary to McCloy's recommendations, Hinton and Rarick concluded that lung capacity was of sufficient importance (increased r by .044) to warrant its continuance in the strength battery, and even as a measure of athletic ability. Their final recommendation of a strength test for girls, with basketball as the criterion measure, consisted of lung capacity, back lift, and arm strength. The multiple correlation of these strength test variables with the basketball test was sufficiently high to predict basketball achievement within a 10 per cent limit above or below the basketball scores. It is recognized that the results of research with girls on motor skills are not equally applicable to boys, but the above results do seem positive enough to at least be considered.

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[1]C. H. McCloy, "The Apparent Importance of Arm Strength in Athletics," Research Quarterly (1934), pp. 3-8.

[2]Evelyn A. Hinton, and Lawrence Rarick, "The Correlation of Roger's Test of Physical Capacity and the Cubberly and Cozens Measurement of Achievement in Basketball," Research Quarterly, Vol. XI, No. 3.

Rogers obtained a correlation of .81 between his Strength Index and the weighted score on ability in a 2-lap run, standing broad jump, running high jump, 8-pound shot-put, basketball foul throw, and throwing baseballs and footballs at a specially marked target.[1] In view of the fact that arm strength is an important part of Roger's Strength Index, and that the arms were highly involved in most of the above skills, it seems logical to assume that arm strength may well contribute to the skill of executing the Pacific Coast one-hand foul shot.

McCloy has observed that strength is the most important element in motor performance.[2] This contention is supported by research evidence obtained by Granger,[3] Stansbury,[4] Shay,[5] Cox,[6] Clark,[7] and Clarke and Bonesteel.[8]

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[1]Rogers, Physical Capacity Tests, 1926.

[2]C. H. McCloy, Tests and Measurements in Health and Physical Education (New York: F. S. Crofts and Company, 1939).

[3]An unpublished study by Walter A. Granger (Valley Stream, New York).

[4]Edgar Stansbury, "A Simplified Method of Classifying Junior and Senior High-school Boys into Homogeneous Groups for Physical Education Activities," Research Quarterly, Vol. 12, No. 4 (December, 1941), p. 765.

[5]Clayton T. Shay, "The Progressive Part Versus the Whole Method of Learning Motor Skills," Research Quarterly, Vol. V, No. 4 (December, 1934), p. 66.

[6]Walter A. Cox, and Kenneth B. Dubois, "The Strength Index in Equating Intramural Teams in Albany, N. Y.," Supplement to the Research Quarterly, Vol. VI, No. 1 (March, 1935), p. 202.

[7]Leonard Clark, "Melrose High School Experiments," Supplement to the Research Quarterly, Vol. VI, No. 1 (March, 1935), p. 111.

[8]Harrison H. Clarke, and Harold A. Bonesteel, "Equalizing the Abilities of Intra-mural Teams in a Small High School," Supplement to the Research Quarterly, Vol. VI, No. 1 (March, 1935), p. 193.

Oesterich equated basketball teams by means of the Strength Index and compared the results with the "choose-up" method.[1] The largest difference in team scores was 16, as compared with 30 for the "choose-up" method; the median difference was 3.4 as compared with 6. Eleven of the 26 games played by the test-equation method, or 44%, ended either in a tie score or with a 1-point difference. The results of this study are surprising inasmuch as the Strength Index was not intended as a measure of basketball ability or as a measure of any other skill. Acknowledging that the foul shot was only a portion of the skill involved in these games, the results, nevertheless, are provocative in view of the fact that arm strength is an important part of the measurements included in the Strength Index, and also that the arms supply a major part of the propelling force in the act of shooting baskets.

It seems worthy of mention that the consistency with which arm-strength measures, such as chins and dips, have appeared in motor fitness and motor ability batteries is further evidence of their potential importance.

Conclusion

The evidence recorded above suggests that the apparent importance of arm strength as it relates to shooting baskets is such as to warrant further investigation in the design of this particular experiment.

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[1] Harry G. Oesterich, "Strength Testing Program Applied to Y. M. C. A. Organization and Administration," Research Quarterly, Vol. VI, No. 1 (March, 1949), p. 4.

Intelligence as a Factor in Motor Learning

Clarke points out that because intelligence testing occupies an important place in education, a number of experimenters in physical education utilizing various tests have attempted to show the relationship between intelligence and physical skill and abilities.[1] He says that in all instances, however, the results have been disappointing, their significance being approximately zero. Consequently, for physical education, the intelligence quotient has proved relatively useless. Attempts have been made, nevertheless, to construct tests of motor intelligence patterned after the concept of mental intelligence. The term "motor educability," popularized by McCloy and referring to the "ease with which an individual learns new skills," has been used to indicate this concept.

Greene, Jorgensen, Gerberich suggest that results have generally indicated that the intelligence quotient is a poor predictor of athletic ability simply, no doubt, because certain native sensory-perceptual abilities important in learning motor skills have not been properly measured, or not at all.[2] They call attention to the fact that in his 1906 series, Binet eliminated most of the sensory-perceptual items, retaining and supplementing the items designed to reflect the higher mental processes of judgment and abstract reasoning.

John, in an investigation of the relationship between physical

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[1]Clarke, op. cit.

[2]Greene, Jorgensen, Gerberich, Measurement and Evaluation in the Secondary Schools (New York, London, Toronto: Longmans, Green and Company, 1935), p. 234.

skill and the general intelligence of college students, concluded that the correlation between the scores of 310 college freshmen on the Johnson Physical Skill Test and those on the American Council of Education Test was found to be zero.[1] Furthermore, there was no correlation between the Johnson scores and academic grades.

Davies, in an investigation of the effect of tuition upon the process of learning a complex skill, gave instruction to an archery class of 20 women students in the skill, and compared it with a similar class which received no instruction.[2] Records were kept for a total of 18 practice sessions that covered a span of three months. The learning curves for the tuition group was consistently superior to that for the non-tuition group, but instruction did not smooth out the irregularities in the curve. A significant correlation between the mental-test scores and archery achievement was found in the tuition group, but not in the control group. For the non-tuition group, achievement was found to be correlated significantly with previous physical education experience and height, whereas these factors were unimportant to the group which received the instruction.

Kulcinski, in a study of the relation of intelligence to learning of fundamental muscular skills, concluded that the relation

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[1] G. B. John, "A Study of the Relationship that Exists Between Physical Skill as Measured, and the General Intelligence of College Students," Research Quarterly, 13, American Association of Health ahd Physical Education (1942), pp. 57-59.

[2] D. R. Davies, "The Effect of Tuition Upon the Process of Learning a Complex Motor Skill," J. Educ. Psychol., 36 (1945), pp. 352-365.

is positive.[1] His group comparisons show a significant degree of learning by the superior group over the normal groups, and sub-normal groups; marked superiority of the normal groups over the sub-normal groups; and a high degree of superiority of the superior groups over the sub-normal groups.

Karpov has this to say about the psychology of remembering and its significance in instruction:

> By concentrating on the lower levels of the memory process bourgeois psychologists, particularly the associationists, have supported a mechanistic approach to instruction and have ignored the conscious processes involved in the acquisition of knowledge and habits. Smirnov concerns himself with voluntary remembering, but not without considering the fact that much that is mastered in the process of instruction is learned involuntarily. In general, however, voluntary remembering is more effective. Smirnov's investigations show that comprehension increases not only the amount but the quality of reproducible material. Remembering is connected with improvement in logical thinking. As logical thinking improves, the child is better able to organize material on a meaningful basis, and thus the capacity to remember is improved. Smirnov studied the effect of exercise from the point of view that it is most effective if it is meaningful, rather than mechanized repetition: i. e., there should not be rote repetition, but constant intelligent learning in the process of practice.[2]

Conclusion

The weight of the evidence indicates that there is little correlation between the intelligence quotient as measured by group intelligence tests and motor educability.

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[1] L. E. Kulcinski, "The Relation of Intelligence to the Learning of Fundamental Muscular Skills," Research Quarterly, 16, American Association of Health and Physical Education (1945), pp. 266-76.

[2] I. V. Karpov, "The Psychology of Remembering and Its Significance in Instruction," Sovetsk. Peded., No. 12 (1949), pp. 116-1122. A review and discussion of psychology of remembering by A. A. Smirnov (Moscow-Leningrad, 1948).

As a result of discussing the potential importance of intelligence as a factor in motor learning with many coaches over a considerable number of years, it is assumed by the author that coaches generally believe, no doubt as based on intuitive judgment, that there are factors in intelligence not identified and measured by standard group intelligence tests that are highly important in the learning of motor skills. This suggests a need for the development of a diagnostic instrument that will properly identify and measure said factors as they relate to motor learning. Apparently little experimentation has been done on mental practice in which the intelligence quotient has been used in equating experimental subjects. It is, therefore, concluded that the intelligence quotient should be included in this experimental design in consideration of the possibility that it may prove more positive when used with mental practice than research disclosed in the case of physical practice.

Kinesthesis as a Factor in Motor Learning

Kinesthesis is defined as the process of recognizing bodily tensions and or movements in relation to what one is doing, or in terms of their relation to some contemplated mode of behavior, sensations of which are received through any or all of the mechanical senses.

Phillips points out that coaches and psychologists seem uniformly to agree that efficient kinesthesis is essential to refined motor performance.[1] Although not as conclusively as might be

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[1]Bernath E. Phillips, "The Relationship Between Certain Phases of Kinesthesis and Performance During Two Perceptuo-Motor Skills," Research Quarterly, 12 (October, 1941), pp. 571-87.

expected, studies do indicate a tendency for the more skilled performer of a specific manual task to test higher on traditional kinesthetic tests than does the less skilled. On the other hand, manual guidance has been shown to be decidedly inferior to visual guidance in learning to reproduce given maze patterns.

There is evidence that with animals, motor patterns do persist and learning can take place even after the kinesthetic sense has been rendered at least partially ineffective; i. e., by sectioning of the spinal cord, and that maze learning is impossible with none other than kinesthetic cues available.

Osgood points out that the term "kinesthesis," which refers quite literally to sensations of movement introspectively determined, has been largely replaced by the term "proprioception," which emphasizes receptor and sensory nerve action neuro-physiologically determined.[1]

Bass found that an individual uses his kinesthetic mechanism less when the eyes are open than when they are closed.[2] This is a particularly significant point since the value of "muscular feel" or kinesthesia is recognized in the learning of motor skills.

Griffith reports on an experiment in which blindfolded individuals were taught to drive a golf ball.[3] In the initial weeks, their progress

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[1]Charles E. Osgood, Method and Theory in Experimental Psychology (New York: Oxford University Press, 1953), p. 29.

[2]Ruth I. Bass, "An Analysis of the Components of Tests of Semicircular Canal Function and of Static and Dynamic Balance, Research Quarterly, 10:2 (1939), pp. 33-52.

[3]Coleman R. Griffith, "An Experiment on Learning to Drive a Golf Ball," Athletic Journal, 11:10 (1931), pp. 11-13.

was said to be comparable to the control group not using the blindfolds. After a period of weeks, however, when the experimental group was permitted to continue their practice without the blindfolds, their progress was noticeably superior to the progress of the control group. The implications of the Griffith study are two-fold: First, it would appear that the instruction in golf to "keep the eye on the ball" has as a prime purpose the maintenance of proper body position during the swinging of the club. Secondly, and in confirmation of Bass' findings, it would appear that the kinesthetic aspects of golf, particularly the swing, are more effectively learned when unaided by visual perception.[1] There is, in the author's opinion, some doubt on this point due to the fact that several coaches have been known to try this procedure with quite unsatisfactory results. It seems logical to assume that the factors of visual perception and kinesthesis, when used together, should complement one another to produce more effective learning than when each factor is emphasized alone. There is first the problem of knowing the correct swing, and then of checking to determine if it has been executed properly. It would seem that two methods of checking should be more efficient than one. A parallel may be drawn with the coaching of boys to bat a baseball. It is a common experience to have players insist that their batting swing felt good to them when it is clearly obvious that, mechanically, their swing was very poor. This poses the question: Just how much reliance can one place upon kinesthesis alone, and still be accurate according to some prescribed motor skill?

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[1] Bass, op. cit.

Louise Roloff, in an investigation of kinesthesis in relation to the learning of selected motor skills, administered eight tests of kinesthesis to two hundred subjects.[1] A battery of four tests was selected and the following regression equation recommended: 75 Balance Stick - Arm Raising - Weight-lifting + 4.7 Arm-Circling + 50. A kinesthetic score was computed for each subject by using this equation. The correlation between motor ability T-scores and kinesthesis scores was found to be .42.

She selected skills clinic and bowling classes for experimental study. The experimental group in each activity was taught by methods stressing the kinesthetic approach. Two classes in each activity were used as controls. At the end of eight weeks of class instruction, no significant differences were found between the control groups and the experimental groups. The experimental skills clinic classes were slightly better in volley ball skill than the control classes; the experimental bowling group showed more gain in bowling ability than the control group, but their final scores were very similar. Initial bowling scores and final bowling scores gave a correlation of a negative .76. No significant correlation was found between kinesthesis scores and motor ability T-scores for tennis.

Werner, as a result of a study of the development of visuo-motor performance on the marble-board test with the mentally retarded, concluded that a highly articulate form organization, consisting of building a complex pattern out of its components, increases in

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[1] Louise L. Roloff, Kinesthesis in Relation to the Learning of Selected Motor Skills (Dissertation abstract of Ph. D. Thesis, University of Iowa, 1952), pp. 12, 715.

incidence with mental age, while performance guided by lines rather than form decreases.[1] This was considered by Werner to signify a shift in dominance of guiding factors from the kinesthetic to the visual field.

Hellebrandt, in reviewing experimental literature on kinesthetic awareness, points out that there is an absence of definitive information of the part it plays in learning motor behavior.[2] He observes that an experimental basis exists for increased understanding and renewed interest in the clinical implications of this phenomenon.

Doreen Lindsay, in an investigation of the relationship between measures of kinesthesis and the learning of a motor skill, concluded that where initial scores were held constant, the amount of learning showed a low positive relationship to kinesthetic perception.[3] There was a low but significant relationship between initial learning test scores and kinesthetic tests, also.

Fleishman, in discussing motor kinesthesis, insists that the existence of this factor still rests upon an insecure basis,

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[1] H. Werner, "Development of Visuo-motor Performance on the Marble-Board Test in Mentally Retarded Children," J. Genet. Psychol., 64 (1944), pp. 269-79.

[2] F. A. Hellebrandt, "Kinesthetic Awareness in Motor Learning," Cerebral Palsy Rev., 15 (1953), pp. 3-5.

[3] Doreen Lindsay, Relationship Between Measures of Kinesthesis and the Learning of a Motor Skill, quoting from Ammons, Perceptual and Motor Skills, 1955 (Berkeley, California: University of California).

although it has appeared in several Air Force Analyses.[1]

Woodworth observes that in learning to typewrite by the touch system, one early builds up a clear image of the keyboard in which each letter can be located.[2] Later one loses this image and can no longer tell where the letters are, though one finds them readily with the fingers in typing, and has a sense of readiness and mastery which amounts to a conscious attitude. He concludes that conscious attitudes seem to represent a stage in a process of development which begins with vivid imaginal thought and slowly and gradually passes downward to a stage of automatic or instinctive control. He further observes that when a person looks for kinesthetic experience he usually finds it.

Levine and Kabat, in discussing proprioception, have this to say:

> Electromyographic experiments are reported to support the role of proprioception in voluntary motion in man. The interdependence of muscles is demonstrated by the overflow of excitation which occurs during resistance to a particular movement. The reflex patterns of movement which are common

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[1]Fleishman, *op. cit.*, 1953, listed the following Air Force Analyses:

J. P. Guilford, and J. I. Lacey, *Printed Classification Tests* (AAF Aviat. Prog. Res. Rep. No. 5, 1947).

A. W. Melton, Editor, *Apparatus Tests* (AAF Aviat. Psychol. Prog. Research Report No. 4, Washington, D. C.: U. S. Govt. Print. Off., 1947).

W. B. Michael, *Factor Analyses of Tests and Criteria: A Comparative Study of Two AAF Pilot Populations*, (Psychol. Mong., 1949) 63, No. 3 (Whole No. 298).

[2]Robert S. Woodworth, *Experimental Psychology* (New York: Henry Holt and Company, 1947), p. 79.

to all species are found in man as components to mass movement patterns even when volition is involved.[1]

Kekchev investigated the role of proprioception in the working process by four methods, the first of them being based on the definition of effort thresholds and space size.[2] The other three methods allowed the evaluation of proprioception by the exactness of movements. Kekchev states that in secondary automatized movements that proprioception plays the leading role.

Conclusion

It is apparent that there is an absence of definitive information of the part kinesthesis plays in the development of motor skill. One can only conclude that it seems to play some part. How much has yet to be determined. The author is led to the conclusion that kinesthesis should be emphasized in this experiment, but he frankly does not know how its degree of influence on the development of the motor skill involved can be properly measured in view of the lack of clear-cut agreement as to just what it is, or how it should be measured.

The Role of Perception in Motor Learning

Gordon defines perception as an awareness of objects present

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[1] M. G. Levine, and H. Kabat, "Dynamics of Normal Voluntary Motion in Man," Permanente Fnd. Naed. Bull., 10 (1952), pp. 212-236. Courtesy of Biol. Abstr.

[2] K. H. Kekchev, "The Role of Proprioception in the Working Process," Fiziol. Zh. U. S. S. R., 19 (1935), pp. 167-72.

to sense; a sensation apprehended and understood.[1] Imagination is said to be an awareness of objects not present to sense.

Butter points out that we get our information about the world from our senses; that the picture of the world is a construct made from the varied sensations which reach the brain.[2] This picture is said to be not a static one, but is constantly enlarged. It involves elements which come from both the present and past sensations. It involves memory, recognition, and a great degree of selection since the human attitude to sense impressions is never a merely passive one.

Eleanor Gibson, after an extensive examination of literature pertaining to perception, observes:

> That perceptual learning occurs under many conditions is clear, as is also the fact that improved skill in discrimination is an important feature of such learning . . . The psychological literature of the past 70 years contains a vast amount of evidence that perceptual judgments can be improved.[3]

She points out that during World War II a need developed in many areas for knowing the potential perceptual skill of a man in judging, such as the size, distance, angle, and speed of obstacles, targets, and other objects in the environment. As the level of the available skill usually left much to be desired, the question at

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[1]K. Gordon, "Perception and Imagination," Psychol. Review, 42 (1935), pp. 166-85.

[2]J. A. Butter, "Pictures in the Mind," Science News, No. 22 (1951), pp. 26-34.

[3]Eleanor J. Gibson, "Improvement in Perceptual Judgments as a Function of Controlled Practice on Training," Psychol. Bull. (1953), pp. 401-31.

once arose as to whether training could improve it. She suggests that the kind of practice which will be most effective in increasing the skill of perceptual judgments is clearly a problem for experimental investigation. In line with this thinking is that of Fleishman, who, as a result of factorial study of psychomotor abilities of U. S. A. F. personnel, concluded that one of the most important findings with respect to learning was the surprising degree of specificity of learning on various superficially similar gunnery trainers and on various apparently similar air-crew tasks.[1] He says: "These findings point very strongly to the need for a careful analysis of the critical requirements for a particular activity, and also emphasize the importance of actual empirical demonstration of the effectiveness of a particular training procedure." Numerous instances were found in which training failed entirely to produce the desired skill in the actual task performed by the air crew. In gunnery especially, much of the work on ground trainers seems to have been largely wasted effort. In a few instances it was found that the training actually produced interference so that untrained individuals were superior to the "trained" ones. As perceptual judgment is a definite factor in aerial gunnery skill, it is logical to assume from these findings that there is something about the native perceptual abilities of the gunnery trainee that was not given proper consideration in the design of the training

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[1] E. A. Fleishman, op. cit., 1953, quoting Army Air Forces Aviat. Psychol. Program Research Reports, Report No. 1, Edited by John C. Flanagan, Professor of Psychology, University of Pittsburgh, (1948), p. 254.

routine. While in the Navy, the author spent considerable time watching gunnery crews practicing shooting at remote-controlled target planes with anti-aircraft weapons. Having practiced shooting with small arms from moving platforms at both stationary and moving targets, the author contends that the interjection of the factor of motion to the gun platform, whether it be a plane or some other device, calls upon a different gestalt of perceptual abilities, which, if true, could well account for the disappointing results of the ground training for gunnery air crews.

Fleishman makes the observation that differences in individual aptitudes are much more important than differences in training for producing differences in individual effectiveness in the typical training situation, and concludes that a greater improvement can be gained in effectiveness in the activity for which the individual was selected and trained by research on selection and classification than by research on training procedures.[1] This generalization appeared to hold for a variety of training situations in the Army Air Force.

Flanagan points out that perhaps the most objective attempt to isolate and classify the variables involved in perception can be found in Thurston's work. He says:

> One large group, mental abilities, may be subdivided as they have been in this volume into intellectual and perceptual categories. All other psychological traits may be arbitrarily included under the heading of temperament, which represents a somewhat amorphous group of traits having at least the one element of emotionality in common. It is becoming recognized that a very important aspect of temperament is that of motivation.[2]

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[1]Fleishman, op. cit., 1953.

[2]John C. Flanagan, Editor, Report No. 5, AAF Aviat. Psychol. Prog. Research Reports (1948), p. 568.

Arthur Siegel has hypothesized that there are three stages in the development of visually dominant cues in perceptual learning.[1] These are a motor-somesthetic stage, a motor-visual stage, and a visual stage. He says:

> If we assume, as Hobb implies,[2] that there are different stages of perceptual learning, we may also assume that the cues utilized at each of these stages are different. It is possible that visual dominance may characterize adult perceptual learning while cues at a tactual-motor-kinesthetic level may predominate in the early stages of learning.

Woodworth has this to say about memory images: "Many individuals possess the power of calling up 'before their mind's eye' pictures of scenes, objects of faces they have seen; they are said to have strong powers of visual imagery. A memory image is typically a lifelike or vivid reproduction of sensory experience."[3] He points out that Fechner was the first to announce the existence of great individual differences in imagery,[4] and later, Galton came out with stronger evidence to support this observation.[5] Fechner asked his subjects to call up an image of a certain object, and found that while some reported success, others were able to get at best a momentary glimpse after which the image gave way to a bare thought of the object. Galton employed the familiar

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[1]Arthur I. Siegel, "A Motor Hypothesis of Perceptual Development," Amer. J. Psychol., 66 (1935), pp. 301-04.

[2]D. O. Hobb, Organization of Behavior: A Neuro-psychological Theory (1949), pp. 317, 321, 326.

[3]Woodworth, op. cit.

[4]G. T. Fechner, Element der Psychophysik, (1860).

[5]E. Galton, Brain (1879), pp. 2, 149-62.

"Breakfast Table" questionary. He asked his subjects to visualize their breakfast table as they had sat down to it in the morning, and to report whether the objects were well-defined, the brightness comparable to that of the actual scene, the colors distinct and natural. It is said that from his first subjects, scholars and scientific men, he obtained answers which surprised and somewhat disconcerted him, for many of them reported an absence of images, and were inclined to regard the "mind's eye" as pure invention of the poets. On distributing his questionary more widely, however, he received many quite different reports. Galton arranged his subjects in the order of their power of imagery as indicated by their reports, and thus was able to show where the average, or median, lay.[1] Woodworth points out that Galton was followed by other investigators who found some individuals strong in visual imagery, others strong in auditory or motor imagery.[2] Thus there grew up a theory of imagery types; the visualist, strong in visual imagery, but weak or mediocre in other forms; the audile, strong in auditory imagery; the motile, and other types.

Stricker discloses considerable evidence relative to the motor type.[3] His word images, instead of being visual or auditory, are described as being almost entirely kinesthetic. There is the question, however, as to whether they are true images or sensations

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[1]E. Galton, Inquiries Into the Human Faculty (1883).

[2]Woodworth, op. cit.

[3]S. Stricker, Studien uber die Sprachvorstellungen (1880), and Studien uber die Bewegungsvortellungen (1882).

from actual articulatory movements. Besides a few "pure types," a "mixed type" was found necessary to take care of individuals who reported imagery of several senses and no marked preponderance of any one modality. Stricker reported that as the investigation progressed, the mixed type was found to be very common and the pure types correspondingly rare.

Betts expanded Galton's questionary so as to give a fair chance for images of every modality using a scale of 7 degrees for subjects to rate images on, as from perfectly clear to no image.[1] The surprising result was that those subjects who ranked their imagery high or low in one sense tended to do about the same in other senses also, so that there was a positive correlation between the reported vividness of imagery of different senses, instead of the negative correlation demanded of the types' theory. The average grade assigned to the visual and auditory images was only slightly higher than the average assigned to the other modalities.

Rosecrans, in his study of the relationship between perceptual performance and the three types of learning tasks, attempted to discover a possible source of variability in human learning when the factors of age, sex, and psychometric intelligence were controlled.[2] The matched pair technique, as based on the above three factors, was the method of subject selection. The learning tasks were: Pursuit

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[1]C. H. Betts, The Distribution and Functions of Mental Imagery (1909).

[2]Clarence Rosecrans, The Relationship Between Perceptual Performance and the Three Types of Learning Tasks (Dissertation Abstract, 1955), p. 15.

rotor, paired associates, and a problem-solving cross puzzle. He concluded that perceptual performance as reflected by the Gottschaldt figures is one source of individual differences, and thus group variability, in human learning when the factors of age, sex, and psychometric intelligence are controlled.

Waters examined the claim that perceptual organization is primary, and reinforcement a secondary process. He suggests the following criticisms against the theory:

1. Perceptual organization is too narrow a concept to account for all forms of learning.

2. The character of perceptual organization is a function of the prior presence of needs or drives within the organism.

3. The establishment of perceptual organization adequate for the control of behavior requires the concept of reinforcement.

4. Though the distinction between learning and performance is theoretically valid, experiments have not satisfactorily established the fact that either can take place in the absence of some form of reinforcement.[1]

As a result of these criticisms, for which he cited experimental evidence from the literature, he concluded that perceptual organization is not sufficient cause or condition for learning.

Boger has done a study that suggests that training in visual perception may enable pupils to react more effectively in situations requiring perceptual discrimination.[2]

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[1]R. H. Waters, "Some Comments on Perceptual Organization as the Theoretical Basis of Learning," <u>Amer. Psychologist</u>, 3 (1948), p. 235.

[2]Jack H. Boger, "An Experimental Study of the Effects of Perceptual Training on Group I. Q. Test Scores of Elementary Pupils in Rural Ungraded Schools," <u>Journal of Educ. Research</u>, Vol. 46 (September-May, 1952-53).

The study also suggested that perceptual training will cause an increase in intelligence test scores of rural elementary school pupils. The extent of improvement in test performance by rural pupils as a result of training indicates: (a) Scores from intelligence tests often gave an estimate of mental ability which is an injustice to these pupils so far as actual ability is concerned; and (b) perceptual training removes some of the handicaps which influence performance of rural children on intelligence tests. It would appear from this study that elementary school children are capable of responding to a more challenging school program than intelligence test scores derived from group intelligence tests frequently seem to justify.

When one considers Boger's disclosure that perceptual training will cause an increase in intelligence test scores of rural elementary school children, it seems logical to assume that the intelligence test scores of a large proportion of all individuals so measured could be considerably improved if said testing were preceded by a high type of perceptual training, which doubtless few have ever received. The author suggests that a need is indicated for extensive research on the potential effects perceptual training may have on intelligence test scores. Such an approach might result in new evidence on the relationship of intelligence to motor skill.

Yacorzynski has proposed that perceptual ability reaches its greatest maturity between the ages of thirty and forty-five, which suggests that, in addition to the potential effects of perceptual training, maturational factors related to perceptual abilities should be taken into careful consideration in the development of new educational techniques.[1]

Crain and Werner, as a result of a study of the development of visuo-motor performance on the marble board, concluded that "Correctness of performance within the age levels considered appears to be clearly a function of chronological as well as mental age."[2] With respect to sequence of moves, they point out that there is a definite indication of a decline in the continuity type procedure as chronological and mental age increase. The continuity type, as it declines, is replaced by the constructive kind of sensori-motor procedure. The experimenters hold that results are in line with developmental theory which implies that earlier and more primitive types of visuo-motor performance agrees with the findings by Rice, one of the few investigators who have attempted to analyze the types of movements made by children while drawing.[3] Rice found that at an early age reproductions are completed predominantly in terms of continuous drawings without lifting the pencil from the paper or breaking the line. As to perceptual organization, the study shows that with chronological and mental growth there is an increase in articulate perceptual behavior, concomitant with the decline of linear types of organization. It therefore seems logical to assume that some

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[1] G. K. Yacorzynski, Medical Psychology (New York: The Ronald Press Company, 1951), pp. 155-57.

[2] L. Crain, and H. Werner, "Development of Visuo-motor Performance on the Marble Board," Pedagog. Semin., 77 (D'50), pp. 217-29.

[3] C. Rice, "Excellence of Production in the Types of Movement in Drawing," Child Devel., 1 (1931), pp. 1-14.

relationship exists between sensori-motor and the mainly perceptual aspects of performance.

Norberg has investigated verbal as well as visual paths to learning, and concluded that visual and verbal paths to meaning are complementary phases in the development of the meaningful situation--not alternative paths to learning.[1]

Geck studied the effectiveness of adding kinesthetic to visual and auditory perception in the teaching of drawing.[2] He points out that an interpretation of the data received through the sense organs to enable the individual to respond to situations and "wholes" rather than to fragmentary items is vitally involved in the learning process. Despite this evidence, teachers of drawing have relied extensively on visual perception in their teaching.

Lowenfeld, while working with visually handicapped subjects, found that artistic expression was not necessarily visual in origin.[3]

Geck points out that one of the greatest exponents of visual and auditory perception for successful teaching in the field of art, Franz Cizek, early in this century in his school in Vienna, supplemented the visual with extensive auditory material to bring out all salient characteristics of the objects to be drawn.[4] The Cizek

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[1] K. D. Norberg, "Visual and Verbal Paths of Learning," Teach. Col. Rec., 54 (Mr'53), pp. 319-23.

[2] F. J. Geck, "Effectiveness of Adding Kinesthetic to Visual and Auditory Perception in the Teaching of Drawing," J. Ed. Res., 41 (O'47), pp. 97-101.

[3] Viktor Lowenfeld, The Nature of Creative Activity (New York: Harcourt, Brace and Company, 1939), p. 272.

[4] Geck, op. cit.

students discussed at length the objects to be drawn before these objects were presented visually, which made for better interpretation of the data received through visual perception. As Sherman has stated:

> To see with perceptual unity is to perceive the whole field of a vision simultaneously, all points being seen in relation to a single focal point. Given the capacity to see in this manner, the problem of learning to draw is to discipline oneself to allow the image, so perceived, to form itself through kinesthetic channels into the eventual drawing.[1]

Floyd Cook, through experiments in teaching drawing to the sightless, came to the conclusion that visual images are not entirely the product of the eye, but are ruled as well by kinesthetic impressions.[2] Geck points out that in several of Cook's uncontrolled experiments there appears to be evidence to support the thesis that reinforcement of visual and auditory perceptions by kinesthetic would prove effective in the teaching of free-hand drawing.[3] In all but one instance, the combined grade of three faculty members was higher for the group of students who had visual and auditory perceptions reinforced by the kinesthetic than for the group that had visual and auditory perceptions only. He concluded: "It would appear that more effective teaching of drawing is possible when all avenues of learning--visual, auditory, and kinesthetic--are made use of." It is suggested by the author that the same should be true in the

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[1]Elizabeth Clymer Okerbloom, "Hoyt Sherman's Experimental Work in the Field of Visual Form," College Art Journal, III (May, 1944), p. 144.

[2]Floyd Cook, "Art Without Sight," School Arts, XLIII (October, 1943), pp. 40-45.

[3]Geck, *op. cit.*

teaching of motor skills of the athletic type.

In a maze learning experiment by Warden, the subjects who reported having depended primarily upon explicit or implicit verbalization learned more efficiently than those who said that they depended primarily upon visual imagery or a motor mode of attack.[1]

Baker and Wylie, in a study of transfer of verbal training to a motor task, designed an experiment so as to minimize the possibility of using implicit motor responses so as to study the effectiveness of a primarily verbal type of mental rehearsal.[2] The motor task used in the experiment was a discrimination learning problem in which the subject learned to press the appropriate one of four switches upon the appearance of a red or green stimulus light in either of two positions. In the verbal training the subject was asked to memorize, by an oral paired associates method, verbal expressions of the final task. Specifically, the experimenter gave two words representing color and position of the light and the subject was to respond with two other words representing the position of the correct switch. During verbal training the subject did not know that a motor task was to follow. No transfer effect was found following small amounts of training in verbalizing the stimulus-response relationships of the motor task; but larger amounts of such verbal training were of benefit to the later learning of the task.

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[1]C. J. Warden, "The Relative Economy of Various Modes of Attack on the Stylus Maze," J. Exp. Psychol., 7 (1924), pp. 243-75.

[2]Katherine E. Baker, and Ruth C. Wylie, "Transfer of Verbal Training to a Motor Task," Journal of Exp. Psychol., 40 (1950), pp. 632-38.

Short did a study on visual and mental imagery in which 150 sugjects were examined with a 2-channel portable electroencephalograph machine during the solution of six different mental tasks.[1] The first channel recorded electrical potentials from the posterior areas of the brain, and the second channel recorded breathing by means of a thermocouple. It appeared that the subjects fell into two main categories of imagery--visual and verbal. The extreme alpha types, P (Persistent) and M (Minus), correlated with extreme types of imagery, and the R (Responsive) type with moderate "imagery," though with a clearly recognizable predominance of visual or verbal images. The visualists tended to breathe regularly and their alpha-rhythms, where present, were blocked whenever they were busy with mental tasks. Visual images were reported as coming more readily to them than verbal ones. The verbalists tended always to breathe irregularly and their alpha-rhythms persisted whether or not they were thinking out problems.

The author ran a pilot study in a few physical education classes in which were obtained initial scores as based on the number of foul shots made out of 25 attempts using the Pacific Coast one-hand foul shot to be employed in this dissertation project. The subjects were then divided into <u>high</u> and <u>low</u> groups, as based on the initial scores, and instructed to take five warmups and 25 shots for score for several school days. A graph of the learning curves of the two groups as based on the cumulative arithmetic mean of shots made each day was computed. On some days, the subjects were allowed to shoot

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[1]P. L. Short, "The Measurement of Mental Images," <u>Sci</u>. <u>News</u>, No. 24 (1952), pp. 7-21.

without first receiving instructions on shooting form. On other days they were given careful verbal instruction emphasizing the factors of knowing, seeing, and feeling, as previously discussed on page 2 of this paper. The learning curves exhibited pronounced inclinations on the days that such instruction was given. A noticeable declination was noted on the days such instruction was not given. An interesting finding was that verbal instruction had a much greater effect on the low group than the high group.[1] It is to be noted that this pilot study was neither comprehensive or extensive enough to provide data on which to base any strong conclusions, but it did suggest the strong potential effect that verbal instruction may have when the aforementioned factors are exploited by an instructor.

Hoisington, as a result of a study of some relationships between factors involved in the perceptual process, has this to say about muscular adjustment in perception:

> 1. External objects are only objectified sensory components giving the following resultants in perception:
>
>   a. Creation of a world of objects through objectivication of sensory experience;
>
>   b. Preparation of the organism to react adjustively in connection with these objects;
>
> 2. All meaning is the muscular adjustment (tonic not phasic) present in perception;
>
> 3. Any reaction, verbal or overt behavior, is a phase of this muscular adjustment;
>
> 4. All postulates and theories are based on the inherent nature of the organism and on modes of functioning inherent in that nature.

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[1]See Appendix C, page 188, for a graphing of results.

5. Factors primarily involved in the perceptual process are stimulus, receptor, sensory experience, muscular adjustment, neural system, and organic organization. The perceptual process is one of dynamic interaction between these factors. The result of this interaction is organic organization, which in turn affects the functioning of the factors.[1]

Conclusions

1. Perceptual judgments involved in the development of motor skill may well be improved by the right kind of training.

2. The kind of training that is best for improving perceptual judgments in any particular motor skill is still a problem for experimental investigation.

3. There is a strong likelihood that there is a high degree of specificity of learning involved in the development of any particular motor skill.

4. Physical educators would do well to carefully investigate their methods of teaching motor skills with special attention being given to the interference factor.

5. Differences in perceptual ability appear to be more important than differences in training for producing differences in individual effectiveness in the typical training situation.

6. A more effective method of teaching motor skills may be achieved when all avenues of learning--visual, auditory, and kinesthetic--are made use of in the training techniques.

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[1] L. B. Hoisington, "Some Relationships Between Factors Involved in the Perceptual Process," Proc. Okla. Acad. Sci., 32 (1951), pp. 125-128.

The Time Factor in Motor Learning

There is a mass of research material available on the effect of different time-patterns of practice in motor learning; evidence of the importance investigators attach to this seemingly important factor.

Barch gave 25 subjects 30 trials on each of two days, separated by 48 hours rest, on the Epicyclic Pursuit Rotor.[1] The distributed practice group had a 45-second rest between each 15-second trial. The massed practice group had no such rest. A five-minute rest was given between each block of six trials for both groups. The massed practice group showed the poorer performance, and the more marked reminiscence between blocks of trials, than did the distributed practice group, indicating that the inhibition from massed practice can develop within 90 seconds of continuous practice.

Riopelle investigated learning on the Vector Complex Reaction Time test for male subjects under conditions of massed and distributed practice.[2] Performance improved steadily, with the distributed practice group increasingly superior.

Tsao had four groups of 16 subjects practice on mirror-drawing for 12 trials.[3] In groups E and G, trials 1-6 were spaced with

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[1] Abram M. Barch, _Permanent Work Decrements in the Performance of a Pursuit Task Arising from Short Periods of Massed Practice_, (U. S. A. F. Hum. Resour. Res. Cent., Res. Bul. 52-2, 1952), p. 5.

[2] Arthur J. Riopelle, "Psychomotor Performance and Distribution of Practice," _J. Exp. Psychol._, 40 (1950), pp. 390-95.

[3] J. C. Tsao, University of Hong Kong, "Shifting of Distribution of Practice in Mirror Drawing," _J. Exp. Psychol._, 40 (1950), pp. 639-642.

one-minute intervals, and trials 7-12 were continuous; in groups F and H, the procedure was reversed. Groups E and F performed the 12 trials in one sitting, and groups G and H each had an overnight interval interpolated between the sixth and seventh trials. He concluded that early massed trials and later spaced practice may be as efficient as, or even more efficient than, early spaced and later massed practice in mirror-drawing.

Harmon and Miller have reported an experiment in which college women without previous experience in playing pool or billiards were used as subjects.[1] This motor learning was set up so that four sub-groups were using different time intervals between practice periods, but with the units of practice, number of practice periods, and the length of practice periods constant. The authors concluded that relative massing at the beginning of the learning process is to be preferred over widely spread intervals at the beginning. Once the foundation had been laid, greater spacing between the practice periods had a more favorable effect upon learning than continued massing.

Knapp and Dixon had two groups of 35 male seniors at the University of Illinois, who were majoring or minoring in physical education, so organized that one group practiced juggling three balls for five minutes each day and the other group practiced 15 minutes every second day.[2]

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[1]John M. Harmon, and Arthur G. Miller, "Time Patterns in Motor Learning," Res. Quart., 21 (Amer. Health Assn., 1950), pp. 182-87.

[2]Clyde G. Knapp, and W. Robert Dixon, "Learning to Juggle: 1. A Study to Determine the Effect of Two Different Distributions of Practice on Learning Efficiency," Res. Quart., 21 (Amer. Health Assn., 1950), pp. 331-36.

All subjects recorded greatest number of successful catches in each practice schedule until they succeeded in making one hundred consecutive catches. This was the criterion of when the subjects had learned to juggle. The results indicate that five minutes daily practice facilitated more rapid learning than fifteen minutes every second day.

Cook and Hilgard had two groups of subjects each practice on the Koerth Pursuit Rotor during three daily twenty-one minute sessions.[1] For one group the rests between one-minute trials decreased progressively from three minutes on the first day to one minute on the second day, to twenty seconds on the third day. For the other group the inter-trial rests increased from twenty seconds to one minute to three minutes on successive days. Distributed practice was notably advantageous on the first day and continued to show some advantage over massed practice on the third day. Following overnight rests, and after a five-minute rest at the end of the third day, scores of the two groups did not differ significantly despite differences in the arrangement of previous practice sessions. It was concluded that overcrowding of trials has a decremental effect on scores both early and late in practice.

Kimble and Bilodeau, in an investigation of work and rest variables in cyclical motor learning, concluded that the effect of varying the length of the work period appears early in learning if maintained at a nearly constant level throughout practice, and that

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[1] Barbara S. Cook, and Ernest R. Hilgard, "Distributed Practice in Motor Learning: Progressively Increasing and Decreasing Tests, J. Exp. Psychol., 39 (1949), pp. 169-72.

performance differences as a function of the length of interpolated rest increase with practice.[1] The joint effect produced by the concomitant lengthening of the work period and shortening of the rest period was held to be a simple summation of the two separate effects.

Gagne concluded from a number of experiments on the problem of massed and distributed practice as they effect learning and retention of motor skills that:

> 1. Performance decrements as a result of massed practice are not a universal finding in the learning of motor skills;
>
> 2. When decrements do occur, they appear early in the course of learning, rather than being built up as the practice period continues;
>
> 3. When the measure is retention, results depend on distribution during retention tests, not conditions during original learning.[2]

Norris, in an investigation of performance of a motor task as a function of interpolation of varying lengths of rest at different points in acquisition, obtained findings that indicate that the point of interpolation of rest affected performance significantly, the shorter pre-rest practice group showing greater gains.[3] Length of rest was not a differential determiner of post-rest performance.

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[1]Gregory A. Kimble, and Edward Bilodeau, "Work and Rest as Variables in Cyclical Motor Learning," _J. Exp. Psychol._, 39 (1949), pp. 150-57.

[2]Robert M. Gagne, _Work Decrement in Learning and Retention of Motor Skills_ (In Floyd and Welford Symposium on Fatigue; see 28:5511), pp. 155-62.

[3]Eugenia B. Norris, "Performance of a Motor Task as a Function of Interpolation of Varying Lengths of Rest at Different Points in Acquisition," _J. Exp. Psychol._, 45 (1953), pp. 260-64.

Adams and Reynolds did a study of the effect of shift in the distribution of practice conditions following interpolated rest, and concluded that the massing of practice does not lead to the development of any permanent decremental states, and that distribution of practice is a performance rather than a learning variable.[1]

George Snoddy, as a result of a mirror-tracing experiment, concluded that there are two distinctly opposed elements in mental growth; primary growth, which comes early and is enhanced by interpolated time, and secondary learning, which comes later and is enhanced by reducing the interpolated time.[2] He seemed convinced that secondary learning, as he called it, gives every impression of being largely motor learning; that its rise is limited to the periods of practice, and loss occurs when time is introduced.

Dore and Hilgard, using the Koerth Pursuit Rotor, investigated spaced practice for the purpose of testing Snoddy's two processes in mental growth, concluded that a condition of increasing rests is more efficient than a condition of decreasing rests as propounded by Snoddy.[3] They expressed strong doubt that Snoddy's mathematical analysis has discovered and defined the two, and only two, processes in mental growth. Noting that two different mechanical mediums of

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[1]Jack A. Adams, and Bradley Reynolds, "Effect of Shift in the Distribution of Practice Conditions Following Interpolated Rest," J. Exp. Psychol., 47 (1954), pp. 32-36.

[2]George Samuel Snoddy, Evidence of Two Opposed Processes in Mental Growth (The Science Press Printing Company, 1935).

[3]L. R. Dore, and E. R. Hilgard, "Spaced Practice as a Test of Snoddy's Two Processes in Mental Growth," J. Exp. Psychol., 23 (1938), pp. 359-74.

investigation were employed, it is suggested by the author that perhaps there was a different combination of factors contributing to the results in each investigation which may well have caused the discrepancy in the respective findings.

Gentry, in an investigation of the immediate effects of interpolated rest periods on learning performance in one of two sets of learning materials under one of five conditions of learning, concluded that the introduction of rests raised the score, and withdrawal of rests lowered the scores at any stage of learning.[1]

One of the chief current theories of the effectiveness of spaced practice is that proposed by Hull.[2] Essentially, his theory looks upon learning as a difference between excitatory and inhibitory processes. Both sets of factors die out with time, but he maintains that the inhibitory tendencies die out more rapidly. The theory states that added rest between trials permits dissipation of inhibitory factors which arise at the time of making a response. This theory of differential forgetting has been substantiated by work on rote learning by Hovland.[3]

To further document evidence regarding the effects of massed and spaced practice from the mass of literature available would be

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[1] J. R. Gentry, Immediate Effects of Interpolated Rest Periods on Learning Performance (Teach. Coll. Contr. Educ., 1940), No. 799, pp. vi + 57.

[2] C. L. Hull, "The Conflicting Psychologies of Learning--A Way Out," Psychol. Rev., 42 (1935), pp. 491-516.

[3] C. L. Hovland, "Experimental Studies in Rote Learning Theory: VI. Comparison of Retention Following Learning to the Same Criterion by Massed and Distributed Practice," J. Exp. Psychol., 28 (1940), pp. 389-587.

only to accentuate what is already very much in evidence, that there is a great diversity of experimental results and judgments.

Conclusion

1. Experimental results are far from conclusive as to the actual effects of spaced and massed practice in the development of motor skills.

2. It is logical to assume from the results available that there is a strong likelihood that there is some optimum time-spacing of practice sessions that will produce the best results in the development of any particular motor skill.

3. An examination of the literature suggests a need for a more comprehensive investigation of the effects of time-spacing of practice sessions in the development of motor skills related to physical education activities.

CHAPTER III

THE DESIGN OF THE EXPERIMENT

Basic Considerations

The prime objective of this experiment was to investigate the effect of mental practice on the development of a motor skill. The author was motivated by the conviction that the experimental design, its execution, and documentation should be carried out in a way that would enable coaches and physical educators to apply the findings to their own activities, and also would encourage further research.

With the above thoughts in mind, and in view of the fact that basketball is one of the most popular games, it was decided that the utilization of a basketball skill as a medium of investigation was a practical consideration.

Simple logic dictates that the particular skill selected should provide a means of investigation in which the factors or variables to be taken into consideration may be carefully examined by sound experimental and statistical techniques.

The Pacific Coast one-hand foul shot was the skill selected as the medium of investigation for the following reasons:

1. The shot is a skill of sufficient complexity to provide a sound testing medium for the hypotheses under consideration;

2. Scoring is simple and accurate;

3. Time considerations of training the subjects, measurement

of their skill, and length of practice sessions may be adjusted to fit into the average high school physical education program;

4. As this particular shot is essentially a one-handed shot necessitating very little body action, it has the potential of good skill being developed in a relatively short period of time;

5. The shot enjoys great current popularity, a fact that may well attract considerable attention to any positive experimental evidence.

Because of the large number of variables, known and suspected, that affect motor skills, the findings documented in Chapter II point out the impractibility of carrying out research of any magnitude on motor skills by means of the old control type of experiment in which an attempt is made to control all the variables but the one being investigated. The additional consideration that each sport skill may well have its own gestalt of variables yet to be determined further complicates the picture. It was therefore decided that an experimental design should be set up that will make possible a careful examination of only a few of the most obvious and important variables pertinent to the problem at hand. Recognizing that influences from unequated variables might become apparent during the experimental procedure, it was considered important to be on the watch for them, and if any did appear, to examine them with an open mind as potential clues to new avenues of research pertinent to this dissertation problem.

Experimental Factors Emphasized

The major objective of this research was to compare a physical practice group with a mental practice group in the development of a motor skill, the Pacific Coast one-hand foul shot. This posed the question of whether or not the intelligence quotient, as measured by a standard group intelligence test, would be an important factor in this particular research project. An examination of literature has disclosed that there is likely to be little or no relationship between intelligence quotients as based on group testing and ability to learn a motor skill. It was decided to equate for the factor of intelligence as based on the intelligence quotient, however, because of the possibility that it might emerge in a new light when an attempt was made to develop motor skill through a mental practice technique.

Of all the factors considered that might exert a strong effect on this research, it was decided that arm strength is supported by the most positive evidence. From the viewpoint of a physical educator, the possibility of determining if arm strength exercises employed in the average physical conditioning program contributed to motor skill in basketball was a provoking one. Recognizing the folly of attempting to prove everything in one piece of research, the decision was made to design the experiment around a careful investigation of one major consideration, the effect of substituting mental practice for physical practice in the development of a motor skill, and the supplemental considerations of the influence of intelligence and arm strength.

An additional variable was eventually given strong consideration, and that was the experience factor. With no reliable method available for determining a subject's past experience in shooting baskets, it was obvious that it was impossible to equate the subjects for this variable on the basis of scores as is possible with the intelligence test and arm-strength scores. Recognizing that the development of a motor skill is a perceptuo-motor growth process, it was reasoned that the problem of equating for the experience factor might be circumvented by selecting three categories of subjects as a basis for comparison that would be based primarily on experience in basketball, namely: Varsity, junior varsity, and novice high school players. This decision now interjected the consideration of another variable, schools, inasmuch as a high school varsity basketball team is rarely composed of more than twelve players, a fact that limited the junior varsity and novice groups in each school to approximately twelve subjects. It was therefore obvious that, if sufficient subjects were to be obtained to provide adequate data in the experiment, it would be necessary to employ varsity, junior varsity, and novice subjects from several schools.

The most logical method of measuring any improvement in motor skill that might result from mental practice appeared to be by dividing the subjects into physical and mental practice groups of near equal ability, as based on the factors of arm strength and intelligence, in an experimental design which would properly take into consideration the additional factors of schools and categories of experience.

The interjection of a number of schools into the experimental design immediately raised the question of how much variability one could expect as to coaching methods, team morale, ability of the individual subjects, the coach's personality and success in handling his players, and the many other intangibles that constitute any individual team's makeup. It being apparent that this was impossible of any accurate determination, the problem became one of selecting an experimental and statistical technique that would somehow provide a means of analyzing the effects that one could logically expect from such variability, or at least in some way make allowance for them.

Statistical Technique Selected

The analysis-of-variance technique developed by R. A. Fisher, and first reported in 1923, constitutes a method capable of analyzing the variation to which experimental and observational material is subject so that an assessment of the various components of variation can be made.[1] Johnson points out that Fisher's technique is

> . . . the only efficient one so far developed by which it is possible to differentiate the variation according to causes or groups of causes and to interpret the significance of a number of components simultaneously. The analysis-of-variance method consists in breaking up the total variance into independent parts which can produce independently the maximum-likelihood estimates of variance due to random effects alone.[2]

A useful extension of the general analysis-of-variance method is the analysis-of-covariance technique, also developed by Fisher.

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[1] R. A. Fisher, and W. A. MacKenzie, "Studies in Crop Variation. II: The Manurial Response of Different Potato Varieties," *Journal of Agricultural Science*, Vol. XIII (1923), pp. 311-20.

[2] Palmer O. Johnson, *Statistical Methods in Research* (New York: Prentice-Hall, Inc., 1940), p. 210.

In this analysis, the process consists in breaking down the sum of products of deviations of any two variates from their means and assigning the respective components to specified sources. This is comparable to the process of breaking up the sum of squares in the case of the analysis of variance. One of the most useful applications of the covariance method is in sorting out the covariance effects of variables, particularly involved in experimentation. This operation makes it possible to increase the precision of an experiment by the elimination of causes of variation in some cases not controlled by the experimental design. This was exactly the problem faced as a result of the interjection of several schools into the experimental considerations. It was therefore a sound consideration to employ the analysis-of-covariance technique in the present experimental design.

Procedure of Administration

With the experimental factors and design decided upon, it was then necessary to devise and administer techniques for the procurement of data.

Schools Selected. A prime consideration in the selection of schools from which the experimental population was to be obtained was that of the degree of interest of the basketball coach and of his players in this research project, and their willingness to participate with assurance of full cooperation throughout the duration of the experiment. A second but equally important consideration was the availability of time, both on the part of the subjects and the schedule of activities in the several gymnasia that would permit the addition of the experimental program. Out of a large number of high schools contacted, five were finally selected that met the above requirements, after full approval for execution of the experiment had first been obtained from all administrative authorities concerned in each school.

Two high schools in Detroit and two from the suburbs were selected for participation. A fifth school was selected and held in reserve in consideration of the possibility that something might occur necessitating an additional replication of the experiment. Four schools were selected for the following reason: Three categories of experience, varsity, junior varsity, novice, of 12 subjects each were to be used. A discussion with several statisticians concerning the number of subjects required to assure a sufficient amount of experimental data led to the conclusion that 36 subjects from each of four schools for a total of 144 would be sufficient. As will be indicated in Chapter IV, this provided a 36-cell factorial grid with four subjects to a cell. It is to be pointed out that the participation of large numbers of subjects in an experiment is not of itself any guarantee of high validity of the data obtained. The efficiency of execution of the experimental techniques was considered as to be of much greater importance than numbers of subjects. It was difficult to obtain the participation of high schools that provided all the necessary conditions for a successful experiment. To have added schools merely to obtain additional subjects could well have jeopardized the validity of the data obtained.

Population Selected. An important consideration in assuring high validity of the data was the selection of subjects that fitted the categories of experience, and yet who would not be participating in basketball during the course of the experiment. To do so would have been to defeat the major objective of comparing a mental practice group with a physical practice group. It was decided that the only logical time for running the experiment would be at the termination of the basketball season. By this time, the varsity and junior varsity teams in each school would be well established as a result of a combination of competition and the subjective judgment of the coaches. As most schools have only short transition periods from basketball into the Spring sports activities, it was reasoned that most of the basketball players would be turning their attention to such activities, a fact that would help to assure non-participation in basketball other than as indicated by the planned experimental procedure.

The selection of the novice group was achieved by asking for volunteers from the regular physical education classes. The requirements for participation were that a volunteer had not had the advantage of organized playing and coaching; that he was a beginner, so to speak, in basketball, and that he professed a deep interest in learning to play the game. An effort was made to select the novices so that the school grades represented were of a somewhat similar distribution to that found on the varsity and junior varsity squads. These were selected by chance drawing from a considerable number of volunteers. The objective of proportioning subjects as to grades was fairly well accomplished in the two suburban high schools. In the Detroit schools, however, the novice groups had a much higher proportion of freshmen due to the fact that the subjects who volunteered and met the requirements of the novice classification were largely freshmen.

Measurement of Arm Strength. The next problem to be solved was that of selecting a method that would most properly measure arm strength, and at the same time provide a range of scores large enough to assure reasonably distinct categories of high, average, and low. It was assumed that three categories of strength would provide a reasonably sensitive measurement for a statistical analysis of the importance of the arm strength factor.

It was decided that Frederick Rand Rogers' formula for measuring arm strength as found in his Strength Index would meet the above requirements.[1] The formula was as follows:

$$\text{Arm Strength} =$$

$$(\text{Pushups} + \text{Pullups}) \times \left(\frac{\text{Weight}}{10} + \text{Height} - 60\right)$$

Measurement of Intelligence. Investigation disclosed that the Short Form of the California Mental Maturity Test is used in a considerable number of the high schools suburban to Detroit, and especially in the first two high schools where this research project was introduced. As test scores for a majority of the subjects in these two schools were already available, and as this particular test could be given with a small investment in time and money, it was a practical

[1]Frederick Rand Rogers, Physical Capacity Tests, 1926.

consideration to base intelligence quotients on this test. It is recognized that the best measure of intelligence cannot be obtained through group testing, but considerations of cost and time dictated against using individual tests such as the Stanford-Binet.

Inasmuch as the Detroit Board of Education administers its own special form of intelligence test, it was necessary to obtain permission from the Board to administer the California Mental Maturity Test in the Detroit schools participating in the experiment. This was obtained through the assistance of Dr. Harry Baker of the Psychological Testing Service. Dr. Baker rendered additional assistance by assigning Mr. Bickle of his department to administer the tests. The author did the rating of the tests and the computation of intelligence quotients.

In line with previous determination that the intelligence quotient so obtained would exert little or no effect on the experimental design selected, it was decided to equate the subjects into a factorial grid on the basis of only two categories, high, low, reasoning that the use of three categories, as in the case of arm strength, would accomplish nothing more than to increase the complexity of the design.[1]

Equating Subjects into the Factorial Grid. The factorial grid, although it will be dealt with in Chapter IV under the heading Treatment of Data, must also be considered at this point because logically the physical and mental practice groups to be employed can only be determined by setting the grid up in preparation for

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[1]See Appendix B, page 138.

the administration of the training and experimental technique.

All the data necessary for properly preparing the factorial grid were collected into tabular form as indicated in Appendix B, page 134. The next step was to organize all the arm strength scores in descending order of magnitude on the left side of the page in separate categories, and the intelligence test scores in descending order of magnitude on the right side of the page opposite the arm strength scores.[1] It is to be noted that the subjects were assigned coded numbers so that individual intelligence quotients would not be disclosed. The problem was now one of selecting subjects to fit the grid as follows: (a) Two subjects high in arm strength and intelligence; (b) two subjects high in arm strength and low in intelligence; (c) two subjects average in arm strength and high in intelligence; (d) two subjects average in arm strength and low in intelligence; (e) two subjects low in arm strength and high in intelligence; (f) two subjects low in arm strength and low in intelligence. This was done separately with the varsity, junior varsity, and novice groups as indicated above.[2] To facilitate the pairing of the subjects according to the aforementioned plan, connecting lines were drawn as indicated in Appendix B, page 138 . A certain amount of forcing was expected to be necessary. This possibility materialized, so the check system used made it much easier to keep track of the pairings and at the same time estimate where the forcing might be done with the least effect on the factors being equated for.

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[1]See Appendix B, page 138.

[2]See Appendix B, pages 142, 146, 150.

Forcing may be explained as shifting the relative rank-order positions of certain subjects as a means of completing the pairings indicated above. For example, it was not possible to find two subjects that paired for average arm strength and low intelligence.[1] The positions of subjects 12 and 6 were interchanged in the intelligence quotient column, thus making it possible to <u>pair</u> subjects 5 and 6 for these two special factors, and also to complete pairings for low arm strength and high intelligence, using subjects 9 and 12. Forcing was done in the intelligence quotient column as much as possible because it had been hypothesized that the factor of intelligence would be found to exert little or no influence on the findings. Therefore, as it was strongly suspected that arm strength might be found to exert a positive influence, it was logical to do the forcing where it would least affect the experimental results, in the intelligence quotient column. An attempt was made to do the forcing within one standard deviation which could be considered within either the bounds of experimental error or of the day-to-day effects that cause variation in such measurements.

Each member of each separate pairing was assigned to a physical practice group or a mental practice group by means of the simple expedient of chance drawing of names from a container. This was accomplished by writing the names of the subjects of each pairing on separate pieces of paper of equal dimensions, shaking these in a container, and then drawing and assigning the first name drawn from each separate pairing to the physical practice group. The second

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[1]See Appendix B, page 138, Varsity Group.

name drawn was assigned to the mental practice group of the subject's respective category of experience.[1]

Experimental Procedure. The first day of the school week, Monday, was selected for the start of the experiment. At this time all the subjects participating were first instructed to read the Group Introduction to the Experiment.[2] They were then given printed information on the Pacific Coast one-hand foul shot to read.[3] The next step was to have the subjects position themselves on a line facing the instructor who proceeded to give them instructions in the shooting technique to be used.[4] At the conclusion of the instructions the subjects were each required to shoot twenty-five consecutive practice shots, during which time the instructor proceeded to correct mistakes observed. When all subjects had completed the practice shots, the basic considerations of knowing, seeing, and feeling, as used in the instructions, were reviewed. Each subject was then instructed to shoot twenty-five shots while striving to make the best score possible. They were informed that this would be considered the Initial Score for the experiment. They were also told that a Final Score would be obtained similarly at the termination of the experiment; that each was expected to strive to improve over his Initial Score as much as possible.

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[1] See Appendix B, pages 142, 146, 150.

[2] See Appendix A, page 123.

[3] See Appendix A, page 124.

[4] See Appendix A, page 125.

The successes, number of shots made out of 25 attempts, were duly recorded on the Physical Practice Group and the Mental Practice Group Record Sheets.[1] Each subject was notified at this time as to which group he had been assigned. Great care was taken to avoid letting any of the Physical Practice Group know what the Mental Practice Group was to do. To help assure this objective, the Mental Practice Group was referred to only as the Experimental Group. The subjects in this group were requested to tell no one about their special part in the experiment.

On Tuesday, the second day of the experiment, the Experimental Group was assembled in private and given the written Introduction to the Mental Practice Technique to read.[2] A few words of caution were added as to the importance of keeping the procedure secret from the Physical Practice Group. They were told that they were to consider themselves as competing against the other group using a new learning technique. A brief description of the Motor Theory of Consciousness was given to support the simple demonstration indicated in the written Introduction to Mental Practice Technique.[3] They were then instructed to carefully read through the Mental Practice sheets.[4] It was explained that each subject was to read through the Mental Practice sheets each day at the beginning of the mental practice

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[1]See Appendix B, pages

[2]See Appendix A, page

[3]E. Jacobson, "Muscular Phenomenon During Imagining," (Electrophysiology of Mental Activities), Am. J. Psychol., 49 (1932), pp. 677-94.

[4]See Appendix A, pages

session even though it was expected that they would no doubt have them memorized in a few readings. It was pointed out that it was hoped that the mental practice engaged in each day would approximate quite closely the time it took the Physical Practice Group subjects to shoot five warmups and twenty-five for score each day. It had been previously determined that to read through the Mental Practice sheets and then to carry on the mental practice indicated in them should approximate in time span that necessary to carefully shoot thirty foul shots. It was recognized, however, that individual differences would necessitate some subjects taking longer than others to properly carry out the instructions, but it was assumed that a somewhat normal curve would result as to the time spent by the individual subjects. It was suggested that each subject do his mental practice at a speed that seemed to suit him best, recognizing that individual differences would operate very strongly as to the ability to concentrate and to visualize or "picture in the mind's eye" the shooting technique called for. In addition, it was pointed out that in similar experiments with mental practice, the subjects had been merely asked to "mentally practice" a motor skill without first having been given specific instructions as to just what the pattern of thought should be. It had been reasoned that this procedure would tend to channel the thinking, increase the concentration, and as a result prevent their minds from wandering. Subjects in previous experiments of this type had reported a tendency for the mind to wander. The prediction was made that the concentration this mental practice technique required would prove difficult for a large percentage of the subjects for the first few days, but that it was believed it would become increasingly less difficult as the experiment progressed and in proportion to the effort expended. A warning was given that the mental practice sessions might become monotonous after a few days, thus weakening their efforts, so a plea was made that the subjects strive to keep their enthusiasm up throughout the course of the experiment.

The author felt concern about the possibility that critics of this study might contend that the reading through of the Mental Practice sheets each day would be in fact a case of instructing the Mental Practice Group, whereas the Physical Practice Group, not reading any such instructions, would therefore be at somewhat of a disadvantage. It was predicted, however, and experimental results bear this point out, that in just a few readings, each subject would report that he had memorized the instructions almost verbatim. The reading therefore served mainly to keep the subject's mind from wandering, an eventuality that was being guarded against. It is also contended that any slight advantage the Mental Practice Group might have gained from this procedure was more than offset by the fact that, because the Physical Practice Group was actually shooting baskets, the misses would be constant reminders of the technical mistakes they had been instructed to avoid. Such reinforcement could well be stronger than that gained from reading the Mental Practice sheets. Actually, there was nothing in the instructions that could not be easily remembered, especially after the training, practice, and test period each subject was submitted to.

The Physical Practice Group was instructed to shoot five warm-ups and twenty-five shots for score for the remaining four days of that school week, and five days each of two additional school weeks for a total of fourteen days beyond the test day. The final test day was scheduled for the fourth Monday, with 25 warmups and 25 shots for score being taken. No instructions were given during the course of the experiment after the first testing day, or on the final test day.

The Mental Practice Group was instructed to engage in mental practice for the remaining four days of that school week, and for five days each of two additional school weeks for a total of fourteen days, with the final test day to fall on the fourth Monday. The final test score of this group was likewise to be obtained by having the subjects shoot 25 warmups and 25 shots for score. No instructions were given to this group at any time after the initial testing day.

All the instructional work at the first high school participating in this experiment was done by the author. It was surprising to have practically every subject report that his Initial Score was either as good as, or, in many cases, better than any percentage they had been able to shoot during the regular season. The fact that there were such high Initial Scores now posed the question as to whether they were the result of the instructional technique used, of the investigator's ability to motivate the subjects, or a combination of both factors. It was suggested that the author train the coach at the next high school participating in the experiment to give all the instruction necessary to proper administration. This was done. No strong conclusions could be drawn from the results, however, because the subjects had been using an underhand foul shot method during the entire season, therefore the opportunity for improvement was greater to begin with than in the case of the first high school where the subjects had been well trained in the use of the one-hand foul shot. At the last two high schools participating in the experiment, the coaches were so busy with their regular school work that it again became necessary for the author to do the instructional work to avoid imposing an extra work load that could well have resulted in a decreased effectiveness of administration of the experimental technique. This decision was a practical consideration also from the viewpoint that there would be one less potentially important variable to contend with--the personality and instructional skill of the coaches.

The number of days selected for carrying out the experiment was the result of the following considerations:

1. A time span was used similar to that employed in the few experiments of a similar nature, previously referred to, as a means of comparison.

2. It had been determined that three weeks was about all that would be available between the basketball, and track, and baseball seasons for properly running the experiment.

It is to be noted that no control group was set up in which subjects were selected for participation on only the first and last days of the experiment with instructions to forget it on the days in between. An examination of literature had disclosed that, wherever this had been done as a means of evaluating the improvement of the subjects under such conditions, the improvement was negligible ranging from -2% to +4% when only a few subjects were involved. This is in line with fluctuations in scoring one would expect on a day-to-day basis. Pilot studies by the author disclosed that with larger numbers of subjects participating in such a control group, there was generally a loss when the subjects engaged in no practice of any kind. In line with the above facts, it was considered unnecessary to select subjects for a control group in which participation would be on only the first and last days of this experiment. Furthermore, to have done so would have necessitated running the experiment in a much larger number of schools if enough subjects were to participate to assure high validity of the data.

Introspective Analysis. A major criticism which has long been leveled against the method of introspective analysis is that, because there is nothing available in the form of overt behavior that may be observed and examined by the customary methods of obtaining and treating data, it therefore cannot be reliable. To put it another way, because the mental processes resulting from introspective analysis are not observable, and because they are apparent only to the person engaged in the analysis, any results must necessarily be considered unreliable. The author does not accept this contention. It is conceded that a person may be trained to become fairly skilled in introspective analysis and therefore provide more accurate data under certain conditions than an untrained person might be expected to. However, it seems conceivable in like turn that there may be occasions when introspective analysis engaged in according to the natural ability and experience of the subject may produce observations and even insights that may give highly reliable clues to further research. With this thought in mind, each Mental Practice subject participating in this experiment was requested to engage in a brief period of introspective analysis. This was conducted by simply having the subjects sit down individually with the investigator in an informal discussion for the purpose of determining what the subject's reactions to the experimental procedure had been. A basic set of questions was kept in mind, but was not used verbatim as a means of interrogation. Instead, the subject was asked to extemporize about his reactions to the experimental procedure as best he could recall them. The questions referred to were injected into the conversation whenever the opportunity presented itself to use them without tending "to put words into the subject's mouth." It was necessary to make terse notes during these introspective analyses for purposes of evaluation.[1] The feeling persists with the author that this note-taking detracted from the effectiveness of the subjects' attempts to introspectively analyze their reactions. It is suggested that it might have been more effective to have used a tape recorder, or at least a secretary inconspicuously positioned in the room, to record the disclosures. The list of questions referred to was as follows:

1. What was your reaction to the experiment when it was first presented to you?

2. Was the mental practice easy or difficult to engage in; that is, did you have any difficulty with concentration, with visualizing, or "mentally picturing" the shooting technique?

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[1]See Appendix C, page 179.

3. Did you notice any change in your ability to visualize or imagine the shooting technique?

4. Did you experience any unusual thoughts, sensations, or hallucinations during mental practice? This question was introduced into the questioning after several subjects had reported unusual hallucinations occurring during mental practice.

5. Did you experience any feeling of monotony at any time during the practice sessions?

6. Did your mind tend to wander at any time during the practice sessions?

7. Were you able to visualize a basket, and the spot on the rim as per instructions? If so, were you able to do so in relation to a normal position on the foul line? This latter question was introduced after several subjects had reported that they had experienced hallucinations in which they fancied themselves watching from a detached position as if they were another person merely observing the shooting.

8. Were you able to imagine making 25 consecutive successful foul shots?

9. Did you experience any gain in confidence as the experiment progressed?

10. What was your reaction when you approached the foul line to shoot your Final Score after not having practiced with a ball for three weeks?

11. Do you feel that the introductory training period and practice helped you?

12. Do you feel that the mental practice helped you?

CHAPTER IV

FINDINGS

Treatment of Data

It will be recalled that in Chapter III, page 66, it was pointed out that one of the most useful applications of the statistical technique of Covariance Analysis is in sorting out the covariance effects involved in experimentation. Such an operation makes it possible to increase the precision of an experiment by the elimination of causes of variation in some cases not controlled by the experimental design. Since this was the problem faced in the present experiment, the Analysis of Covariance Technique was employed as the design for this study.

In order to carry out the analysis, it was necessary to establish the factorial grid shown in Table I. The Initial Score and the Final Score are denoted on the grid by X and Y, respectively. The two groups are denoted by M for mental practice, and P for Physical practice. The three classes are denoted by V for varsity, J for junior varsity, N for novice. The two categories of intelligence are denoted by α for high, and β for low. The roman numerals I, II, III, IV denote the four schools which participated in the experiment.

In order to facilitate the understanding of the analysis,

TABLE I

FACTORIAL GRID

Arm Strength	Intelligence	Groups	School I						School II					
			Classes						Classes					
			V.		J.V.		N.		V.		J.V.		N.	
			Measures						Measures					
			X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
H	α	M	19	16	16	15	11	12	13	17	8	11	17	17
		P	9	20	13	13	11	12	5	17	10	16	10	16
	β	M	12	14	16	13	11	13	14	16	5	5	7	15
		P	9	19	13	13	6	14	15	19	8	13	8	13
A	α	M	14	9	16	12	7	10	13	19	14	19	11	11
		P	14	13	4	10	15	15	13	16	10	12	7	13
	β	M	20	16	16	15	6	9	16	17	15	14	17	15
		P	24	21	9	13	11	10	18	15	16	13	8	14
L	α	M	18	16	14	14	7	7	13	21	9	9	8	7
		P	11	18	13	17	6	4	12	17	11	14	13	9
	β	M	17	12	13	14	2	11	13	15	10	14	11	18
		P	24	21	7	10	6	8	18	19	11	11	5	13

Arm Strength: H (High), A (Average), L (Low).
Intelligence: (High), (Low).
Groups: M (Mental), P (Physical).
Measures: X (Initial Score), Y (Final Score).
Classes: V (Varsity), J.V. (Junior Varsity), N (Novice).
Schools: I, II, III, IV.

TABLE I (Continued)

FACTORIAL GRID

Arm Strength	Intelligence	Groups	School III						School IV					
			Classes						Classes					
			V.		J.V.		N.		V.		J.V.		N.	
			Measures						Measures					
			X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
H	α	M	8	17	19	21	15	21	14	19	10	16	10	11
		P	17	20	10	18	8	15	16	18	17	21	8	18
	β	M	14	20	10	17	8	12	8	18	6	15	14	16
		P	18	18	18	15	7	7	16	19	14	17	15	15
A	α	M	19	20	17	19	12	12	17	19	12	15	6	10
		P	17	17	18	18	9	16	20	20	16	18	5	15
	β	M	18	21	11	21	9	10	16	16	13	13	10	11
		P	18	13	16	18	14	15	15	18	3	16	7	14
L	α	M	15	19	7	17	8	8	12	17	5	9	6	10
		P	13	22	15	22	11	16	20	20	14	15	6	11
	β	M	18	18	11	16	12	11	15	18	9	12	7	16
		P	17	20	14	20	7	12	18	18	16	19	12	14

the subscripted measures (X, Y) were defined as follows:

X_{aigcs} = the initial score of the individual of the sth school in the cth class of the gth group of the ith intelligence and the ath arm strength.

Y_{aigcs} = the final score of the individual of the sth school in the cth class in the gth group of the ith intelligence and the ath arm strength.

In the above definitions, a = 1, 2, 3; i = 1, 2; g = 1, 2; c = 1, 2, 3; s = 1, 2, 3, 4.

The next action was that of attaining all the sums of squares and products required for the analysis shown in Table XXII, Appendix B. These are listed in Appendix B, pages 167-176, together with the notation for each quantity. An illustration is also provided in Appendix B, page 177, to show how these values are obtained.

The application of the method involves the calculation of sums of squares of the dependent variable (Y), the independent variable (X), and the sums of products of the independent variable with the dependent variate. The dependent variable (Y) is then adjusted, or reduced, and the F-ratio applied to test the Null Hypotheses. These values are obtained by applying the appropriate formulas in Table XXII, Appendix B.

The significance of the interaction is tested first. The complete analysis resulting in the tests of significance of the several hypotheses is given in Table II. The Null Hypothesis being tested is each case is expressed in general terms and is found in a footnote at the bottom of Table II.

For the interested reader it should be noted that through the process of adjusting the dependent variable (Y) for the independent variable (X) from the error (highest order interaction) term, one degree of freedom ascribed to error has been used in the computation.

The reduced sum of squares assigned to error (highest order interaction) is divided by the corresponding number of degrees of freedom to obtain the mean square (3.128). This value was the appropriate one for testing the significance of the other interactions.

The complete analysis of variance and covariance of the final scores, and the partialing out of the effect of the initial score (X) is presented completely in Table II. The whole procedure of making an exact test of significance based on the reduced ΣY^2 is illustrated by the test of significance for "group" in Appendix B, page

Results of Treatment

No significant interactions were found from the error term 1 down through the interaction of arm strength by intelligence by school, Term 7 in Table II. In the case of arm strength by intelligence by class a significant interaction was found at the 1% level. In the 10th term, the interaction of arm strength by school by class was in doubt. Had the statistical technique of "confounding" been applied, possibly this interaction might have been found significant. However, it was not the aim of this research to employ "elegant" statistical treatments at the expense of a more meaningful exposition of the findings.

TABLE II

TEST OF SIGNIFICANCE OF INTERACTIONS

Source of Variation	D.F.	ΣY^2	ΣX^2	ΣXY	D.F.	Reduced ΣY^2	Mean Square	F-Ratio	Null Hypothesis
1. Arm Strength x Intelligence x School x Class x Group	12	51	122	45	11	34.41	3.128	- - -	- - -
2. Arm Strength x Intelligence x School x Class	12	104	131	99	12	38.63	3.219	1.03	
3. Arm Strength x Intelligence x School x Group	6	10	68	-1	6	16.40	2.733	- - -	
4. Arm Strength x Intelligence x Class x Group	4	20	20	19	4	7.75	1.938	- - -	
5. Arm Strength x School x Class x Group	12	66	147	37	12	57.60	4.800	1.53	
6. Intelligence x School x Class x Group	6	25	75	26	6	16.00	2.667	- - -	
7. Arm Strength x Intelligence x School	6	45	68	17	6	41.38	6.897	2.20	
8. Arm Strength x Intelligence x Class	4	62	9	-18	4	73.03	18.258	5.34	Rejected (.01)
9. Arm Strength x Intelligence x Group	2	4	33	9	2	1.78	.890	- - -	
10. Arm Strength x School x Class	12	55	137	35	12	100.88	8.407	2.69	In Doubt
11. Arm Strength x School x Group	6	84	65	-16	6	96.10	16.017	5.13	Rejected (.01)

TABLE II (Continued)

TEST OF SIGNIFICANCE OF INTERACTIONS

Source of Variation	D.F.	ΣY^2	ΣX^2	ΣXY	D.F.	Reduced ΣY^2	Mean Square	F-Ratio	Null Hypothesis
12. Arm Strength x Class x Group	4	77	44	40	4	50.07	12.518	4.00	Rejected (.05)
13. Intelligence x School x Class	6	53	143	21	6	53.29	8.881	2.84	In Doubt
14. Intelligence x School x Group	3	9	14	4	3	7.94	2.647	- - -	
15. Intelligence x Class x Group	2	19	14	15	2	9.12	4.560	1.46	
16. School x Class x Group	6	88	152	24	6	87.22	14.537	4.65	Rejected (.05)
17. Arm Strength x Intelligence	2	41	31	34	2	16.80	8.400	2.69	
18. Arm Strength x School	6	25	46	20	6	16.44	2.740	- -	
19. Arm Strength x Class	4	74	146	55	4	53.28	13.320	4.26	Rejected (.05)
20. Arm Strength x Group	2	10	34	19	2	.33	.165	- -	
21. Intelligence x School	3	34	4	3	3	32.31	10.770	3.44	In Doubt
22. Intelligence x Class	2	12	49	13	2	8.92	4.460	1.43	
23. Intelligence x Group	1	6	17	-10	1	13.78	13.780	4.41	In Doubt
24. School x Class	6	135	82	72	6	84.49	14.081	4.50	Rejected (.05)
25. School x Group	3	37	114	37	3	25.10	8.367	2.67	

TABLE II (Continued)

TEST OF SIGNIFICANCE OF INTERACTIONS

Source of Variation	D.F.	ΣY^2	ΣX^2	ΣXY	D.F.	Reduced ΣY^2	Mean Square	F-Ratio	Null Hypothesis
26. Class x Group	2	2	19	6	2	.14	.070	- -	
27. Arm Strength	2	31	77	-6	2	39.95	19.975	6.39	Rejected (.05)
28. Intelligence	1	3	6	-4	1	6.46	6.460	2.06	
29. School	3	241	63	76	3	178.45	59.483	19.02	Rejected (.01)
30. Class	2	631	853	734	2	585.35	292.675	93.57	Rejected (.01)
31. Group	1	34	4	2	1	33.06	33.060	10.57	Rejected (.01)
TOTAL	143	2088	2787	1407	142	1786.46			

*1. The null hypothesis that is being tested concerns the variation in the same row. For example, the hypothesis regarding Arm Strength x School x Group (line 3 above) is that there is no significant interaction between arm strength, intelligence, school, and group when the effect of the initial foul shooting score has been partialled out.

2. The null hypothesis that is being tested concerning the variation in the same row where only one factor appears (rows 27, 28, 29, 30, and 31; arm strength, intelligence, et cetera, respectively) is that there is no significant difference between the factor's means when the effect of initial score has been partialled out.

Considering other interactions which were significant at the 1% and 5% levels, it is to be noted that interaction term 11, Arm Strength x School x Group, and term 12, Arm Strength x Class x Group, were significant as were term 16, School x Class x Group, and term 19, Arm Strength x Class. Only one other interaction, term 24, School x Class, was found to be significant.[1] The most important results of the analysis were those that led to the conclusion that there was a significant difference between the means of the adjusted final scores of the arm strength, school, class, and group categories. It is of particular interest that the latter three were significant at the 1% level, while the factor of arm strength was found to be significant at the 5% level. These findings corroborated the original contention that these factors might well be found important when mental practice was substituted for physical practice in the development of a motor skill. The factor of intelligence, as based on measurements obtained from the Short Form of the California Mental Maturity Test was found to exert no statistically significant influence.[2] This finding was in line with the prediction that such would be the case.

Having completed the above statistical analysis, the data compiled on the Master Data sheets were now examined by means of simple mathematical procedures to determine the answers to several practical questions.[3] The major objective of this research was to compare the

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[1]See Table II.

[2]See Term 28, Table II.

[3]See Appendix B, pages 134-137.

effect of mental practice with that of physical practice in the development of a motor skill. An examination of Table IV indicates that mental practice, as carried out in this experiment, was effective. It is to be noted that the Average Gain of the Varsity and Junior Varsity Mental Practice groups was nearly as great as that of the equivalent Physical Practice groups in Table III.

It is also to be noted that negative results were experienced by the Varsity and Junior Varsity Mental Practice groups of one school, the first to participate in this experiment. It is suggested that the following factors may have been the cause of the negative results indicated:

1. The instructional technique employed at the beginning of the experiment had produced initial scores for the varsity and junior varsity subjects which a few reported equal to and a majority better than any percentage they had been able to shoot during the regular basketball season. These unexpectedly high initial scores placed an additional burden of proof on the mental practice technique;
2. The attitude of the subjects in this first school may well be described as curious, willing to participate, but with strong doubt as to the potential value of mental practice for developing motor skill.
3. A large percentage of the varsity and junior varsity subjects in this first school were participating in spring sports activities with several subjects being members of both the track and baseball teams. An extremely rainy spring had resulted in cramped game and meet schedules near

the end of the school year at which time this experiment was carried out. Preoccupation with said baseball games and track meets might possibly have detracted from the effectiveness of the mental practice. Final examinations and graduation exercises were also being prepared for.

The results of the other three schools' participation in the experiment, where no such conditions existed, lend credence to this possibility.

It is considered important to point out that, as a result of the first phase of the experiment, there was a gain in confidence by the author as to expected positive results from both the mental and physical practice techniques, and no doubt also in skill in training the subjects in the experimental procedure. This could well have resulted in a transmission of confidence in the physical and mental practice techniques to the subjects in the succeeding phases, which in turn resulted in a greater experimental skill on the part of the subjects. In line with this thinking, it is interesting to note that when the Average Gain of the Varsity and Junior Varsity Mental Practice groups of Schools II, III, IV is computed to the exclusion of School I, that the average per cent of improvement for the Varsity Mental Practice groups changes from 19% to 28%, and the Junior Varsity Mental Practice groups from 23% to 38%. These figures, when considered with the fact that the results in Schools II, III, IV show considerable uniformity as contrasted with School I, suggest the strong possibility that mental practice has a greater potential than the per cents of improvement in Table IV indicate.

TABLE III*

IMPROVEMENT OF THE PHYSICAL PRACTICE GROUPS OF THE FOUR SCHOOLS IN TERMS OF BASKETS AND PER CENTS

School	V. Gain/I.S.	V. %	J.V. Gain/I.S.	J.V. %	N. Gain/I.S.	N. %
I	21/91	23	17/59	31	8/55	14
II	22/81	27	13/66	20	27/51	53
III	10/100	10	20/91	22	25/56	45
IV	8/105	8	21/85	25	34/53	64
Total:	61/377 Av.Gain =	16%	71/301 Av.Gain =	24%	94/215 Av.Gain =	44%

TABLE IV*

IMPROVEMENT OF THE MENTAL PRACTICE GROUPS OF THE FOUR SCHOOLS IN TERMS OF BASKETS AND PER CENTS

School	V. Gain/I.S.	V. %	J.V. Gain/I.S.	J.V. %	N. Gain/I.S.	N. %
I	-17/100	-17	-8/91	-9	18/44	41
II	23/82	28	11/61	18	12/71	17
III	23/92	25	36/75	48	10/64	16
IV	25/82	30	25/55	45	21/53	40
Total:	54/356 Av.Gain =	15%	64/282 Av. Gain =	23%	61/232 Av.Gain =	26%

Gain = Number of baskets improvement over Initial Score
I.S. = Initial Score
% = Per cent of improvement.

* For analysis of group improvement based upon adjusted means, see Appendix C.

Note: See Table XXXII, Appendix C, for breakdown of Initial Scores of all subjects participating in experiment.

As to why the per cents of improvement of the Novice Mental Practice groups of Schools II and III were so much lower than in the case of Schools I and IV is a matter of conjecture. The obviously indifferent attitude of a few of the subjects in the first few days of the experiment is suspected as a contributing factor. Their enthusiasm for the mental practice technique increased after a few days, but perhaps not in time to achieve the improvement from mental practice they might have if their interest had been higher at the start. There is also the consideration that, although the subjects in all the Novice groups met the requirement of Novice, as defined for the experiment, some could have had more informal experience in basketball. Certainly the Initial Score of the Novice Mental Practice group of School II was considerably higher than those of Schools I and IV. From this fact, one might theorize that there was less chance for improvement. However, the Novice Mental Practice group of School III with a much lower Initial Score improved by the same amount.

The author is unable to account for the comparatively low per cent of improvement for the Junior Varsity Mental Practice group of School II. As this group received its training for the experiment late in the school day, fatigue and an unusual amount of confusion in the gymnasium at that time may have resulted in these particular subjects being more poorly trained in the experimental technique. The low Initial Score suggests this possibility.

It is to be noted that subjects 7 and 4 of the Novice Mental Practice group, School II, had initial scores of 17, which is exceedingly high for the novice category.[1] In fact, upon being

[1]See Table XIX, Appendix B.

questioned, these particular subjects admitted participating in frequent back-yard basketball scrimmages, but were insistent that they had been very poor foul shots up to the time of their participation in the experiment. They were equally insistent that the instructional technique had helped them to "suddenly find my shooting eye." This being true, it can be assumed that mental practice was effective at least in causing these two subjects to maintain a higher degree of shooting skill than they had been able to achieve previous to their initial scoring attempts in this experiment.

Considering the fact that the varsity subjects had just recently completed a long basketball season, coupled with the fact that most of the subjects reported their Initial Score for the experiment as higher than any shooting percentage they had been able to achieve during the regular season, the author was frankly surprised at the amount of improvement experienced by the Varsity Mental Practice groups of Schools II, III, and IV.

In consideration of the fact that the subjects were selected for this experiment on the basis of three categories of experience, the question was raised as to whether or not the Varsity group subjects would be consistently stronger in the arms than the Junior Varsity and Novice group subjects, and especially the latter. Several critics of this experiment, assuming that such would be the case, suggested that not to take this into consideration would result in a weakness in the experimental design. It may be recalled that this point was previously discussed, and the prediction made that the Novice groups might well be as strong as, or even stronger in some cases, the Varsity groups. A comparison of the totals of the arm strength scores of the three experience categories of each of the four schools substantiates this prediction.[1] It is to be noted that the total arm strength scores of the Novice groups in three of the four schools are larger than the Junior Varsity arm strength scores of the respective schools, and that two out of four of the novice groups have total arm strength scores larger than the Varsity groups of their respective schools. It is also to be noted that the Novice group of School III had the second highest total arm strength score of all the categories in the four schools represented.

It is not known whether the arm strength scores would correlate with measures of total body strength. Such a consideration is held to be unimportant in this particular research inasmuch as the Pacific Coast one-hand foul shot is essentially just that. Body action contributes little to the mechanics of the skill.

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[1] See Table V.

TABLE V

COMPARISON OF TOTALS OF THE ARM STRENGTH SCORES OF THE FOUR SCHOOLS

School	Varsity	Jr. Varsity	Novice
I	8305	5578	6096
II	7847	6256	9911
III	10527	7422	10864
IV	12773	9506	5405

It was assumed at the beginning of this research that the selection of subjects on the basis of varsity, junior varsity and novice groups would result in three reasonably distinct categories as regards the experience factor. An examination of the initial scores, as indicated in Table VI, discloses just how well this assumption worked out.

TABLE VI

COMPARISON OF THE TOTALS OF THE INITIAL SCORES OF THE FOUR SCHOOLS AS BASED ON 300 SHOT ATTEMPTS BY EACH EXPERIENCE CATEGORY

School	Varsity	Jr. Varsity	Novice
I	191 (63.6%)	150 (50.0%)	99 (33.0%)
II	163 (54.5%)	127 (42.4%)	122 (40.6%)
III	192 (64.0%)	166 (55.3%)	120 (40.0%)
IV	187 (62.3%)	140 (46.4%)	106 (35.3%)

A surprisingly small range of only five baskets is to be noted in the case of the varsities of schools I, III, IV. The lower score in the case of School II can be accounted for by the fact that the subjects of this particular school had been required to shoot fouls during the regular season by the time-honored under-hand-from-between-the-legs method, which fact would result in these subjects having less skill in the one-hand foul shot method than the subjects of the other three schools. The wide range of scores noted in the case of the Junior Varsity groups can be accounted for by the fact that in the case of School II and IV, there was a high percentage of very inexperienced players.

Simple mathematical averages of the total initial scores made by the Varsity, Junior Varsity, and Novice groups of the four schools indicate values of 183, 146, and 112, respectively. This is a difference of 34 baskets or 11% between the average of the shots made by the Novice and Junior Varsity groups, and of 38 baskets or 13% between the Junior Varsity and Varsity groups. These data are a graphic testimonial of the degree of success attained in selecting three reasonably distinct categories of experience.

To supplement the findings in the preceding Analysis of Co-variance concerning the relative unimportance of the intelligence factor, as measured for this particular experiment, Table VII and Table VIII were set up as a means of comparison between the total intelligence quotients of the three categories of experience for the four schools in both the Mental and Physical Practice groups.

TABLE VII

COMPARISON OF THE TOTALS OF THE INTELLIGENCE QUOTIENTS OF THE PHYSICAL PRACTICE GROUPS OF THE FOUR SCHOOLS

Schools	Varsity	Jr. Varsity	Novice
I	600	618	583
II	628	623	639
III	619	623	569
IV	644	679	642

TABLE VIII

COMPARISON OF THE TOTALS OF THE INTELLIGENCE QUOTIENTS OF THE MENTAL PRACTICE GROUPS OF THE FOUR SCHOOLS

Schools	Varsity	Jr. Varsity	Novice
I	538	665	587
II	645	626	650
III	628	643	608
IV	655	739	680

When the figures in Table VII and Table VIII are compared with the per cents of improvement of the Physical Practice groups and the Mental Practice groups, as indicated in Table III and Table IV, there is certainly no positive indication that intelligence, <u>as measured for this experiment</u>, was a factor in the improvement of the scores.

A search of the literature pertinent to this dissertation problem had disclosed that in the few experiments run on the effect of mental practice in developing motor skills, considerably more time was used in mental practice than in physical practice. It may be recalled that an attempt was made in this experiment to encourage the subjects to utilize approximately the same amount of time in both the physical practice and the mental practice groups. They were instructed, however, to mentally practice five warmups and twenty-five shots for score at w hat seemed a natural pace for each individual because of the fact of individual differences. This posed the question as to how closely the time spent by the mental practice groups would approximate that spent by the physical practice groups. Table IX indicates the answer to said question. The average time spent by the physical practice group subjects was approximately six minutes a day.

TABLE IX

AVERAGE NUMBER OF MINUTES OF MENTAL PRACTICE PER SUBJECT PER DAY FOR THE FOUR SCHOOLS

Schools	Varsity	Jr. Varsity	Novice
I	10.9	11.5	10.8
II	8.0	7.5	7.3
III	9.0	13.6	12.4
IV	10.2	10.4	9.5

It has been determined from the above data that the disparity between the time spent in physical practice and mental practice in this particular experiment was much less than in the experiments of a similar kind previously referred to in this dissertation.[1]

Concern has been expressed by several critics of the study concerning the fact that the author had informed the subjects of each school of the other schools' participation in the experiment. The point was made that inter-school rivalry may have had an untoward effect on the results as regards mental practice. The author frankly does not share this viewpoint. Such an approach was used as a means of stressing the importance of the experiment, and of possibly stimulating high morale in the experiment. The subjects were not informed as to the experimental results of any school, until after the experiment had been completed, so this could not have had any effect on the results. A special check with the subjects of the various schools participating disclosed that inter-school rivalry had little or no effect on the degree of enthusiasm with which each person participated in the experimental routine. The novelty of the experiment, and the hope of individual improvement, were found to be the prime factors.

Findings Resulting from Introspective Analysis

It may be recalled that introspective analyses were conducted by simply having the mental practice subjects sit down individually with the investigator in an informal discussion for the purpose of deter-

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[1]See Chapter II.

mining what the subject's reactions to the experimental procedures had been. A basic set of twelve questions had been prepared for these discussions, but were not used verbatim as a means of interrogation. Instead, the subject was asked to extemporize about his reactions to the experiment as best he could recall them. The questions referred to were interjected into the conversation whenever it was felt necessary to draw the subject out on some point he had not volunteered information on. Terse notes were taken of the <u>kinds of observations</u> made by the subjects, and have been grouped under the questions considered pertinent to them.[1] The general findings from the introspective analyses were as follows:

1. When the experiment was first introduced to the subjects, various reactions were observed, ranging from "thought it was a joke," to "considered it important."
2. The subjects experienced varying degrees of difficulty in concentrating during the mental practice sessions.
3. The range of ability to visualize the shooting technique was especially pronounced. The impression was gained that a majority of the subjects derived a major portion of the benefit from the mental practice sessions in approximately the first seven days of the experiment. This observation is based on the fact that the subjects reported varying degrees of difficulty in visualizing the shooting technique for about a week, after which they were able to imagine shooting baskets with a fair degree of facility.

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[1]See Appendix B, page 179.

The implications from this observation were considered important enough to warrant a special phase of the experiment being run as a check, with the subjects from the fifth high school that had been selected, equated, and held in reserve, being used. In this special experiment, the mental practice subjects were instructed to take physical practice shots on each Monday for the duration of the experimental procedure. The general findings have been included in Appendix C, pages 197-200, for anyone interested in them as a basis for future research. It is to be pointed out here, however, that an examination of the data of Tables XXVII and XXIX, and XXX, that mental practice apparently became increasingly effective as the experiment progressed.

4. Several subjects experienced hallucinations during mental practice sessions that were interesting.[1]
5. Several mental practice subjects reported lameness developing in the shooting arm, and a few even in the leg on the same side, following each mental practice session for the first few days of the experiment. They were all insistent that they had done no physical exercise that could have caused such lameness. All were of the opinion that the mental practice had something to do with it. It is to be noted here that during mental practice sessions these particular subjects had been observed apparently unconsciously tensing the hands and muscles of the shooting arm. Several

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[1]See notes, Appendix B, pages 179-187.

of these same subjects, while engaged in introspective analysis, reported that they had suddenly become conscious of this reaction during the mental practice sessions, and had found it necessary to exert considerable attention to avoiding said reaction so as to comply with the instruction that they were to make no motions during mental practice. It is also to be noted that the above reactions occurred with subjects who reported considerable difficulty at first in imagining the shooting technique. These subjects apparently applied themselves to the mental practice technique with great intensity.

6. Monotony affected the subjects involved in the mental practice in varying degrees. A majority of the subjects were especially affected during the third week of the experiment. Impatience about having to wait to find out if they had improved in shooting ability was reported as a common experience at this time.

7. Several subjects reported having their minds wander, but not any of them for more than a few seconds at any one time.

8. It was expected that the majority of the subjects would give an affirmative answer to the question "Were you able to visualize making twenty-five consecutive perfectly executed foul shots?" This was not the case, however. Only a few of the subjects made an affirmative answer. The majority instead reported varying degrees of difficulty and success in making imaginary shots. Most of them

reported a progressive increase in ability to visualize the shooting technique, and a parallel increase in confidence in the possibilities of mental practice. There was also a concomitant increase in imagined number of baskets made out of twenty-five imaginary shot attempts. A few reported a rise and fall in imaginary scores made during successive mental practice periods. The subjects generally reported that when misses were "pictured in the mind" they sensed just what the mistake was in shooting technique that caused them. The effect of mental practice most emphasized was a growth in confidence that their ability to shoot foul shots was improving. A majority of the subjects, in approaching the foul line for the first time in three weeks to shoot the final test score, reported that "I knew just what to do," and that "I felt as if I had been shooting every day."

9. The most positive answers of any were given to the question, "Did the introductory training period help you?" All reported that the instructional technique used had given them a much better knowledge of how to shoot foul shots than they had previously possessed, and that in most cases their Initial Scores were higher than percentages they had formerly been able to attain.

10. Most subjects reported that they felt mental practice had helped them when asked the question: "Do you feel that the mental practice technique has helped you?" The most noticeable thing observed in relation to this question was

the fact that the final test-shooting had disclosed a majority of the subjects had developed a surprisingly acute sense of recognizing even small mistakes in shooting technique as they were made. It was the consensus of opinion that, in view of what had been learned during the experiment, physical practice would now result in considerable additional improvement.

The above notes were couched in general terms. The notes in Appendix B, page179 , state the exact number of subjects when only a small number were involved in an unusual observation. The author recommends that anyone especially interested in the hallucinated experiences would do well to read notes in Appendix B.

CHAPTER V

SUMMARY

Experimental Design

The purpose of this study was to compare the effect of mental practice with that of physical practice in the development of a motor skill, the Pacific Coast one-hand foul shot.

The most logical method of measuring any improvement that might result from mental practice appeared to be by equating the subjects into physical and mental practice groups of near equal ability for the factors of arm strength and intelligence in preparation for an experimental design which could properly take into consideration the following additional factors: (a) Schools, (b) Classes, or degree of experience, as categorized by the terms Varsity, Junior Varsity, and Novice, and (c) Measures, as indicated by Initial Score and Final Score.

The experiment was carried out in two high schools in Detroit, and two high schools suburban to Detroit. The 144 subjects involved were considered sufficient to provide a valid experiment providing there was a careful execution of detail throughout. The degree of excellence of the experimental technique was considered to be of much greater importance than number of subjects. A fifth school was set up for the experiment and held in reserve in preparation for the possibility that something might occur during the course of the experiment necessitating the use of an additional replication.

On the first day of the experiment, all subjects participating were trained in the shooting technique to be used. The considerations of <u>knowing</u>, <u>seeing</u>, and <u>feeling</u> were emphasized as of prime importance.[1] After the subjects had read the printed instructions and had also been given verbal instructions, each took 25 practice shots during which time the instructor proceeded to correct any mistakes observed in the shooting technique. When all subjects had completed 25 practice shots, instructions were carefully reviewed by the instructor, whereupon the subjects were required to take 25 shots while striving to make the best score possible. They were informed that the score thus achieved would be considered the Initial Score.for the experiment. They were also informed that a Final Score would be obtained at the termination of the experiment for the purpose of measuring improvement.

The subjects of the Physical Practice group were instructed to shoot five warmups and 25 shots for score during each of the remaining four days of that school week, and during the five days each of two additional school weeks for a total of fourteen days, with the final test day falling on the fourth consecutive Monday. Their Final Score was obtained by having each subject shoot 25 warmups and 25 shots for score. No instructions were given to this group on the final test day. The subjects of the Mental Practice groups were instructed to "mentally practice" five warmups and

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[1]See page 2.

25 shots for score for the remaining four days of that school week, and the five days each of two additional school weeks for a total of fourteen days, with the Final Score obtained in the same way as the Physical Practice group.

Analysis of Covariance was the method selected for the treatment of data. This operation made it possible to increase the precision of the experiment by the elimination of causes of variation not controlled by the experimental design. The data were also examined by means of simple mathematical procedures as a means of determining the answer to several practical questions, and for purposes of graphic illustration.

Findings from the introspective analyses suggested the possibility that mental practice exerts a major part of its effect in a shorter time span than the three weeks used in this experiment. A majority of the subjects apparently developed enough skill during the first seven days of elapsed time to visualize the foul shot in their mind's eye with a fair degree of facility. It was therefore considered important to run a special version of the experiment as a check on the above observation. It may be recalled that subjects had been selected from five schools on the same criterion and equated by the same method for factors of arm strength and intelligence. The subjects of four schools were used in the main experiment with the subjects of the fifth school being held in reserve. These reserve subjects were now employed in the proposed special phase of the experiment. All experimental detail involved in this special phase was the same as that of the main body of the experiment, with one exception--the mental practice subjects were required to take physical practice shots on every seventh day of the experiment. It was recognized that several replications of this special phase must be run before sound conclusions could be made, but it was felt that important clues might be disclosed which could be used as the basis for future research. This is in line with one of the objectives of this paper, i.e., to stimulate further research. The general findings of this special version of the experiment may be found in Appendix C, pages 197-200. It is to be pointed out here, however, that an examination of the data of Tables XXVII, XXIX, and XXX indicates that mental practice apparently became increasingly effective as the experiment progressed.

Conclusions

1. Both the Physical and Mental Practice groups showed highly significant gains, with t-values of 10.5 and 7.7, respectively.

2. Comparison of physical practice with mental practice shows that physical practice resulted in average gains of 16% for the Varsity groups, 24% for the Junior Varsity groups, and 44% for the Novice groups, as compared to those of the Mental Practice groups which had average gains of 15%, 23%, and 26% for the equivalent categories. Thus mental practice was almost as effective as physical practice for the Varsity and Junior Varsity groups, and not as effective for the Novice groups.

3. There was a significant difference between the means of the adjusted final scores of Arm Strength, School, Class and Group. It is of particular interest that differences in the case of the latter three factors were significant at the 1% level, while the factor of Arm Strength

was found to be significant at the 5% level. These findings corroborated the original contention that these factors might well be found important when mental practice was substituted for physical practice in the development of a motor skill.

4. The factor of intelligence, as based on the intelligence quotients obtained from the Short Form of the California Mental Maturity Test, exerted little or not any influence on the results of the experiment.

5. The introductory training period, the purpose of which was to teach the subjects how to make better use of their perceptual abilities for the development of motor skill, was highly effective.

6. The subjects apparently represented a wide range of ability to visualize, or picture in the mind's eye, the shooting movements of the basketball skill involved.

7. Mental practice caused certain subjects to experience unusual hallucinations of the shooting technique.

8. Mental practice resulted in a growth of the ability to visualize, or picture in the mind's eye, the shooting technique for a majority of the subjects.

9. A majority of the mental practice subjects introspectively experienced a progressive increase in confidence in their ability to shoot foul shots.

10. Mental practice resulted in a majority of the subjects developing an acute sense of instantly recognizing mistakes made in technique by the time of the actual shooting of baskets for the Final Score at the termination of the experiment.

11. There may well be some optimum combination of physical and mental practice sessions that will have the greatest potential for

improvement of any particular motor skill.

Implications for Further Study

It has been suggested that the personality and instructional skill of the author was a highly important factor in the success of this experiment. Such an observation is a recognition of the potential importance of the human element in teaching, which no doubt did have some effect on the subjects participating. This poses the question as to which was more important--the personality and instructional skill of the author, or the basic instructional and experimental techniques used. The feeling persists with the author that the latter factors were the more important. No conclusions should be drawn on the above observations until such time as a series of replications of this experiment have been carried out with a different coaching personality administering each.

It may be recalled that in addition to emphasizing knowing, seeing, and feeling as defined for the purpose of this experiment, simple analogies were drawn as a means of emphasizing particular parts of the shooting technique.[1] The subjects generally reported that said technique gave them an immediate and much improved knowledge of how to shoot foul shots, and that they also experienced at the same time an increase in confidence in shooting ability, because, as many said: "I knew just what to do for the first time."

The results of the introspective analyses by the mental practice subjects suggest a strong relationship between the subject's

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[1] See Appendix A, pages 125-129.

ability to visualize, or mentally picture, the motor skill, and the amount of improvement experienced during the experiment. Further research on this particular observation involving sound methods for measuring the basic perceptual ability of each subject for the purposes of comparison seems essential before any final conclusions may be drawn.

It may be recalled that several subjects experienced unusual hallucinations of the shooting technique during mental practice. Reports of observations made of these particular subjects by educators previous to the experiment and also during the experiment, when compared to the introspective reports, suggest deviations in personality makeup as a possible partial cause of the hallucinations. Psychological and/or physical trauma, possibly early in the subject's history, may have been a contributing cause in some cases. It is suggested that the mental practice technique employed in this research may be improved in a way to make possible a screening of subjects for both perceptual and personality characteristics. It might develop that a major advantage would be that subjects could be screened for such possible traits without their awareness that such a screening was occurring; that is, the diagnostic technique could be submerged in the administration of regular physical education evaluation programs. There is the additional consideration that subjects with untrained perceptual abilities coupled with a highly competitive enthusiasm may have experienced frustration that caused the emotions to become keyed up to a point where hallucinations resulted. Introspective reports, disclosing that most of the hallucinating subjects experienced a progressive increase in ability to visualize the motor skill as a result of mental practice with a consequent disappearance of the hallucinations, lends credence to this possibility.

In comparing the time spent in mental practice with the amount of improvement gained from it, generally speaking, it appears to the author that the subjects spending the most time in mental practice experienced the most improvement, other factors being nearly equal. It is suggested that further research relative to this particular observation is necessary before any final conclusions can be drawn relative to the time factor. It is assumed that there is an optimum amount of mental practice that will produce the best results, other factors, like perceptual ability, being equal.

As to whether or not the method employed in this experiment for measuring arm strength is the best is a matter of conjecture. It was considered adequate for the purpose at hand. As to whether or not some other measure, such as a simple measure of triceps strength, would be more adequate, is a matter for future research to decide.

It may be recalled that in equating the subjects by the Paired Groups technique for arm strength and intelligence, whenever forcing was necessary it was done in the intelligence quotient column.[1] This procedure was followed because it had been decided that the forcing would have less effect on the experimental results than if it were done in the apparently more important arm strength column. This proved to be the case.

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[1]See Appendix B, bottom of Table X.

It appears that, generally speaking, the subjects in the higher intelligence brackets were able to visualize the shooting technique during mental practice with greater facility than the average subject in the lower brackets of intelligence. There were a few pronounced exceptions observed that brought to mind research relative to the "perceptual idiot" type of subject. It was not felt that any conclusions could be drawn on the above observations until such time as further research has been carried out in which there are enough subjects available to eliminate the need for forcing, and also in which special effort has been directed towards a sound evaluation of the basic perceptual abilities of the subjects.

It has been suggested that the results obtained by the author while working with the special rehabilitation cases referred to in the Preface may have been primarily the result of hypnotic suggestion, and that even the results of the mental practice technique employed in this experiment had their basis in hypnotic suggestion. The power of suggestion is not denied. In fact, it is suspected that it is one of the most important elements of good teaching. That the power of suggestion was a factor in the success of this experiment can hardly be doubted. There is grave doubt, however, that <u>hypnotic suggestion</u> was a factor! Cooper and Tuthill did a study concerning time distortion in hypnosis and motor learning that provides evidence by contrast to support this contention.[1] The purpose of their study was to determine whether learning a new motor skill could be facilitated by purely hallucinated practice under conditions

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[1] L. F. Cooper, and C. E. Tuthill, "Time Distortion in Hypnosis and Motor Learning," <u>J. Psychol.</u>, 34 (1952), pp. 67-76.

conditions of time distortion in hypnosis. Introspectively, the subjects felt that such practice was real and that they had obtained practice effects equal to actually doing it; however, objective evidence failed to back up this feeling of improvement. In contrast, the rehabilitation cases referred to by the author in the Preface had introspectively reported increased feelings of confidence resulting from the mental practice which were accompanied by actual improvement in the motor skill being practiced. It is true that said cases were also undergoing standard physiotherapeutic treatment, but it may be recalled that they did apparently conscientiously indulge in mental practice between as well as during the regular sessions of physiotherapy in accompaniment with manipulative exercises. Now this experience, in and of itself, cannot be used as proof that the mental practice was the cause, or even a factor, in the physical improvement of these cases. The results were provocative enough, however, to stimulate the research represented by this dissertation. Whereas the Cooper and Tuthill subjects experienced no actual improvement in skill concomitant to the feelings of improvement engendered by hallucinated practice of a motor skill under conditions of time distortion in hypnosis, a majority of the subjects in the experiment at hand experienced improvement as a result of mental practice of a motor skill, and concomitant to feelings of improvement engendered by said mental practice. Recognizing that the two experiments employed different motor skills as the medium of investigation, and that there are other experimental differences, it is felt that no final conclusion can be drawn at this time as to whether or not hypnotic suggestion of some sort was a factor in this particular experiment although the evidence does suggest that it was not. The above considerations are provoking of research directed toward an investigation of the effects of purely hallucinated practice of the Pacific Coast one-hand foul shot while under hypnotic suggestion. It is predicted that in any such research the results will not measure up to those of this experiment in which the basic processes of knowing, seeing, and feeling were emphasized while the subjects were under the control of their own will power. In fact, it is even more strongly predicted that, without the subjects first being trained in these basic processes, pure hallucination of practice of the one-hand foul shot while under hypnotic suggestion will produce no improvement in said skill.

In the review of literature, it may be recalled that auditory and kinesthetic paths to learning were discussed in addition to visual paths and that the following conclusion was made: "It appears that a more effective method of teaching motor skills may be achieved when all avenues of learning--visual, auditory, and kinesthetic--are made use of."[1] This approach was used in the present study. Although the resulting findings were positive and certainly encouraging, they cannot be considered as conclusive. Further research is needed to determine what the true potential of combining these particular paths to learning actually is.

It may be recalled that a study was reviewed in which 150 subjects were examined with a 2-channel portable electroencephalograph

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[1]See page 49.

machine during the solution of six different mental tasks.[2] The first channel recorded electrical potentials from the posterior areas of the brain, and the second channel recorded breathing by means of a thermocouple. It was reported that the subjects fell into two main categories of imagery--visual and verbal. Inasmuch as both visual and verbal paths to learning have been emphasized in the review of literature, the findings of the above study provoke the thought that it would be practical to carry out research in which electroencephalograms be prepared in conjunction with mental practice experiments like, or similar to, the one represented by the present study. It would be especially interesting to find out if the brain-wave patterns of subjects suffering hallucinations of the motor skill technique during mental practice would be altered as a result of mental practice.

In the study at hand, a number of subjects were observed having apparently involuntary overt muscle activity induced as a result of the mental practice, which brings to mind Jacobson's study (see Chapter III, page 74) relative to the Motor Theory of Consciousness, in which he employed an oscillograph device to measure implicit muscle activity. Research is hereby suggested in which implicit muscle activity be measured by an oscillograph device during mental practice of a motor skill with the following question in mind: Will there be an increase in intensity of implicit muscle reactions in the case of those subjects introspectively reporting a progressive increase in confidence in ability to shoot foul shots during the

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[1]Short, "The Measurement of Mental Images."

course of the mental practice experiment?

It appears that the concomitant use of the factors of knowing, seeing, and feeling exerted an effect on the development of the Pacific Coast one-hand foul shot through mental practice which was magnified out of all proportion to what could normally be expected if each factor were emphasized separately. Further research on the potential of this approach to teaching motor skills is certainly indicated.

In final conclusion, every effort was made to carry out the experimental procedure as much in line with the best traditions of research as practical considerations would allow. The experiment was so designed as to permit an intensive examination of data, not only by simple mathematical computations, but also by the exact requirements of the Analysis of Covariance technique. In addition, introspective analysis was employed. The cooperation of the basketball coaches, the physical education directors, and especially of the subjects participating, was a heartening experience. Morale throughout the duration of the experiment was generally excellent. The subjects have testified that the instructions were carried out to the best of their ability. There is no known reason for questioning their affirmation that they did so. The point is hereby made that, although the findings of this experiment strongly supported its hypotheses and predictions, and much was learned about the possibilities of mental practice, the study is at best but an initial probing into the realm of mental practice through the special experimental technique employed. The author humbly hopes that the knowledge gained and presented will provide an advanced outpost for further investigation and research on the possibilities of mental practice as a method of developing motor skills.

The author is firmly convinced that the findings of this study provide a sound basis on which coaches and physical educators may work to improve their instructional skill, and to lessen the number of hours necessary to develop athletic skill in their charges. He recommends that special attention be given to an investigation of mental practice in relation to the time patterns of practice presented in Table XXXI, Appendix C, believing that patterns of combined mental and physical practice will be discovered for the various motor skills that will prove far superior to the instructional methods used generally today.

It is the contention of the author that the instructional and mental practice technique used in this experiment resulted in a development of neural patterns for the skill being practiced to a degree that eliminated the need for much of the long periods of trial-and-error learning that most athletes progress through. In other words, train the athlete to use his perceptual ability so that he can clearly sense in his mind's eye the specificity of motions for the skill desired, and much trial-and-error learning can be eliminated in teaching motor skills. The problem then becomes largely one of sharpening that skill, and of general conditioning.

The author firmly believes that the experimental procedure used for this dissertation can be developed for use in general physical education classes to a degree that many athletes will be "discovered." Many students, formerly neglected, may then be developed to a degree that they may enjoy the stimulating benefits of athletic participation, if not in varsity competition, at least on teams in organized recreation, such as the intra-mural, club, or community kind.

It is gratifying to the author that this dissertation has disclosed so much potentially valuable information as to the effectiveness of mental practice in teaching motor skill in athletics and physical education. It is even more gratifying, however, that the results strongly indicate that mental practice could well have been a most positive factor in the physiotherapeutic treatment of the rehabilitation cases referred to in the Preface. The author is now firmly convinced that extensive research on the potential of mental practice in physiotherapy is strongly indicated. The confidence engendered by mental practice can provide a powerful psychological crutch, often so desperately needed in the hospital ward. That there are other potential benefits is clearly evident from the results of this dissertation.

APPENDIX A

I. GROUP INTRODUCTION TO THE EXPERIMENT

II. INTRODUCTION TO THE PACIFIC COAST ONE-HAND FOUL SHOT

III. INSTRUCTIONS FOR THE PACIFIC COAST ONE-HAND FOUL SHOT

IV. INTRODUCTION TO THE "MENTAL PRACTICE" TECHNIQUE

V. "MENTAL PRACTICE" WORK SHEET

APPENDIX A

GROUP INTRODUCTION TO THE EXPERIMENT

It is the fond hope of Mr. Clark and I that you will volunteer to participate and with complete cooperation in a scientific experiment that will involve sixteen successive school days. The reasons for running this experiment are several. The results may have very important implications for the future from several viewpoints which cannot be disclosed to you at this particular time without destroying the scientific procedure we must follow if this experiment is to be a success. Suffice it to say, Mr. Clark's studies have produced facts that pose some very provoking questions that, if answered by this experiment, may well produce some very important scientific results. I can at least tell you this much: that you fellows, by participating and exactly as we ask you to, may well give great impetus to a very important phase of scientific research that could well have an important bearing on such fields of endeavor as your own athletic activities, training methods in several fields of industry, aviation, and even in the field of medicine.

You will be divided into two groups for the purpose of this experiment. You must promise not to communicate with anyone about your part in this experiment until it is completely finished. To do so will be to waste not only your effort, but several years of Mr. Clark's that went into preparing for this experiment.

There is an increasing and almost desperate need for thousands of young scientists to be trained in this country. Perhaps the participation in this experiment may awaken an interest in, and the possibilities of, you training to meet that need.

I feel certain that your curiosity will become aroused to a point where you will be very much tempted to discuss your part in this experiment with someone else, or at least to ask someone about their part in it. Again, I implore you: Please do not communicate with anyone about the experiment until it is completely finished. When it is completed, I will then disclose to each and every one of you just what it is all about, and your important part in it.

As the experiment progresses, please do exactly as you are instructed to do each day while this experiment is in progress.

Note: The basketball coach of each respective school participating in the experiment introduced the author just after the subjects had completed reading the above.

INTRODUCTION TO THE PACIFIC COAST ONE-HAND FOUL SHOT

It is a physiological fact that less adjustment and coordination is required in executing the Pacific Coast one-hand foul shot than in other forms of foul shooting. The outstanding characteristics of this shot are:

(1) The wrist and hand movement;
(2) the arm movement, and
(3) the foot position.

Most of the good one-hand shooters prefer to shoot off the right foot with that foot advanced. Because of the right foot being advanced, a shot is obtained that is free from body action and almost wholly dependent upon good wrist and arm movement. The advanced position of the right foot gives the shooter the same position at the time of release of the ball that he assumes at the finish of his shot in both the layup shot and the ordinary push shot from the floor. This point of consistency has been greatly overlooked. The only other point of importance about the feet is that they should be well balanced, the exact position being determined in large part by what position feels the most comfortable to the individual. As the shot is taken, the player should spring up on his toes slightly to insure rhythm, relaxation, and coordination.

The position of the ball is of great importance in this shot. The ball should be brought up to a point in front of the right shoulder. As the shot is started with the two hands the ball should be held close to the body and dipped slightly forward, with the left hand still in contact. This is done for the purpose of "breaking the wrist" to obtain relaxation and rhythm. As the shot is started, the motion by the arm should be an upward vertical movement and not a lateral one. This vertical movement makes for a medium-arched shot which should be aimed at and over a spot on the front of the rim. Concentrate on the target. As the ball is released from the fingers, it is assisted by a hinge-like action of the wrist with an extended action of the arm. This shot is a wrist and arm shot with very little assistance from the rest of the body except a slight knee bend which is coordinated with the "breaking of the wrist."

Note: All Control and Experimental subjects are to be required to read the above printed information.

APPENDIX A

INSTRUCTIONS FOR THE PACIFIC COAST ONE-HAND FOUL SHOT

The following instructions are to be given to all subjects in each school participating in this experiment, and as closely as memory will allow without giving the impression of "parroting," or merely "mouthing" words. The instructions should be coached in a careful, forceful manner that bespeaks confidence in the technique being presented, and slowly enough to make every point clear to all subjects. Subjects are to position themselves side-by-side along a floor-marker (line) facing the instructor who starts the training period sans a basketball as an instructional tool.

Instructions

I am about to train you fellows in a specific technique, that of shooting the Pacific Coast one-hand foul shot. For the purpose of this experiment, you are to pay careful attention to knowing, seeing, and feeling each specific position and motion in the total sequence of positions and motions that make up this particular shooting form. You are to concentrate on knowing, seeing, and feeling (muscular feel) as intensively as possible so that you will later be able to visualize, or picture in your mind's eye, this particular shooting form.

The first point to be considered is that of the position of the feet. The toes of my left foot, you will notice (instructor assumes position), are approximately six inches to the left of and even with the heel of my right shoe, the right foot being placed forward as I am right-handed. I know that this particular position is the best one for me because as I lean forward slightly at the waist so as to bring a small amount of pressure on the ball of my right foot as is proper for this shooting form, and as I rotate my body slightly in this position (demonstrate), I feel in balance in all these slight changes of position. This test of position plus experience in using this form has taught me that this firmly balanced stance is the best for me. I know that this is the best foot position.

Now each of you fellows is an individual as to body build so you will have to determine the exact foot position that is best for you within reasonable approximations of the position I have assumed. Will you please stand up to the line as if it were a foul line with your right foot forward if you are right-handed, and your left foot forward if you are left-handed. Now adjust your feet as you rotate your body slightly while in the proper forward-leaning position (demonstrate) until you feel you have assumed your best balanced stance, which gives you a sensation of firmly planted feet from which you could jump upward with power if you so desired. With your feet in the position you have selected, and while maintaining the forward-leanimg-from-the-waist stance, look intensely at the position of your feet and of your body so as to build a picture in your mind's eye. Now move your body about slightly and pay close attention to the muscular feel of this position doing so with eyes both open and closed. You should now know this position, being able to see it and feel it in your mind's eye when you concentrate on it.

The next point of consideration is that of the position of the hands and fingers, and of the arms in their proper relation as to positions and sequence of motions making up this shooting form. Now imagine that you are taking a basketball in your hands in preparation for shooting a foul shot. The left hand should hold the ball with the palm up and the fingers and thumb well spread and slightly curved upwards so that the ball rests firmly on the tips much as if the left hand was supporting a tray full of water glasses. The left arm is bent up and across the front of the body so that the left hand is palm up in a position approximately waist high and in front of the right armpit (instructor demonstrate). Imagine yourself bowing with arm across the waist much as gentlemen of a bygone era used to when introduced to a lady. Now with the left hand in this position, right hand for the lefties (have all subjects participate), look at it, and sense the muscular feel of this position so as to build a picture in your mind's eye. Now merely flex your shooting arm straight upward from the elbow until it assumes what should be a pushing position on the back of an imaginary basketball held in the left hand. Note that my right hand is so held that the fingers are well spread and slightly curved, and that the palm faces directly forward. The shooting hand should be held almost directly in front of your right shoulder, if right-handed, and the left shoulder, if left-handed.

We should now come to know why our right arm should be placed in this particular position. Let me ask you a question as a means of making a point. Suppose that you are out driving and your car gets stuck in the mud. The passengers get behind the car to push it back into the road. Should they stand upright with arms widespread while pushing, or should they instead push against the car with arms held quite close to their sides? (The subjects will answer in favor of the second position. Now ask them why, and then make the following point.) Is it not a case of your developing the most power or leverage for pushing by assuming that position? (Subjects will agree.) You agree then that the right arm can exert the most leverage or power when pushing straight forward from the shoulder? Now is it not true that the more potential power that is made available the more easily the ball may be pushed up to the basket, and the more easily the ball can be pushed up, the less the amount of muscular strain that will result? Is it not also true that the less straining there is in pushing the ball up to the basket, the greater the accuracy should tend to be because over-straining affects accuracy? Also, does it not stand to be true that if the forward foot, the ball, the shooting hand and arm are all in line with a spot on the front of the basket, the chances for pushing the ball off to one side are reduced providing a smooth forward push is imparted to the ball?

The next point of consideration is what is referred to in basketball as breaking the wrist, which is nothing more than a slight dipping of the ball downward as a result of wrist action only. Now what is the purpose of breaking the wrist? Is it to produce a fancy shooting motion, or is there a more sound reason? (After several observations have been made by the subjects, make the following point:) The purpose of breaking the wrist is to reduce muscular tension that builds up while one is assuming the proper shooting stance. A smoother shooting motion should result after breaking this tension. Now let us practice the wrist-breaking motion together. Do not exaggerate it. Break wrist only enough to loosen up the arms and wrists. While practicing this motion, look at your hands to build a picture in your mind's eye. Now pay careful attention to the muscular feel, both while looking at your hands, and with your eyes closed. With this motion fixed in your mind, coordinate a second motion with it, that of a slight leg dip (demonstrate). As you break your wrists downward coordinate a slight leg-dipping motion downward, and then back upward as wrists proceed back upward and on into delivery of the ball toward the basket. You should sense a smooth flowing motion from the legs up through the body, and then on up through the shooting arm to the point of release of the ball toward the basket. The leg-dipping helps to break body tension and is basic in the series of free-flowing motions that comprise this particular shooting technique.

Now if we know, see, and feel the coordinated wristbreaking and leg-dipping motions so that they are stored in our mind's eye, let us consider the next sequence of positions and motions. The ball is carried from the wristbreaking motion straight upward in both hands to a point where the left shoulder will start tilting if the left arm goes any higher. At this point the shot should become strictly a one-hand shot, the right hand pushing up at approximately an eighty-five degree angle with a wrist-snapping forward motion of the hand at the height of the reach so that the three middle fingers push up and forward across the bottom of the ball towards the target so as to impart a slow backspin to the ball. Such a backspin will produce a dead ball--one that lands with little of the tendency of the ricocheting action of a rapidly spinning ball. The result is that the ball will often land on the rim dead and topple in, whereas a rapidly spinning ball will more than likely miss unless well within the rim when it hits. At the height of your reach in this shot, imagine the similar gracefully extended arm position found in the ballet. While executing this shot, I believe it will help you to think of the relaxed gracefulness of the ballet dancer, because this shooting form is based on a smooth-flowing gracefulness in the execution of the sequence of motions of which it is comprised.

Let us now take a basketball in hand (there should be a number available) and review the sequence of positions and motions just described to you. As to handling the ball, there is one point I would like to make at this time. Perhaps the best way to make the point is by asking a question: Thinking back to the gangland type movies you no doubt all have seen many times, do you recall the typical scene where some hoodlum is preparing to crack a safe by first rubbing his finger-tips on his clothing, some object, or even sandpaper before proceeding to manipulate the dial? Why did he do this? (Allow several observations by subjects, and then make this point:) Was it not true that the hoodlum was striving to increase the sensitivity of his finger-tips where the sense of touch is most acute? Am I not therefore correct in observing that we stand to develop a better feel of the ball when we properly utilize our sense of touch which you agree is greatest in our finger-tips? (Instructor should now repeat the above instructions, this time demonstrating with an actual basketball while the subjects also use one while following through the sequence of positions and motions as he describes and demonstrates them. Emphasize <u>knowing</u>, <u>seeing</u>, and <u>feeling</u> as before.)

The final point to be considered and a very important one is: Just what do we aim at? Do we look at the backboard and the basket, just the basket, or at a point on the basket? Again, let me ask a question or two to help make a point. Let us imagine that we have gone hunting for deer in northern Michigan. We take our rifles and walk into the wilderness. We soon come to a mountain on which we see a deer. Now do we aim at the mountain on which we see the deer? (Subjects will grin, point out the answer is obvious, and say "deer.") Do we aim at the deer, or some particular spot on that deer? (Answers will affirm the latter.) You agree then that if we are to make a clean kill, we should aim for a certain spot; in this case, just behind the shoulder of the deer? With this picture in mind, then let us compare the backboard to the mountain, the basket to the deer, and a small spot on the front of the rim to the heart of the deer. Once you have assumed the proper shooting stance, the eyes should be focused intensely upon a small spot on the front (center) of the rim until the ball has been released from the finger-tips. Never watch the flight of the ball during the execution of the shot, only the target, that small spot on the front of the rim.

Each subject is now to take 25 practice shots in succession, striving to execute all the points I have made during this period of instruction. (Instructor is to make corrections of mistakes in shooting technique during the progress of the practice shots.) When all subjects have completed 25 consecutive practice shots, the instructor will carefully review the positions and sequence of motions of this shooting form.

Each subject will now take 25 shots endeavoring to make the best score possible. The number of shots made out of the 25 attempts will be tabulated as your Initial Score in this experiment.

No further instruction is to be given during the remainder of this experiment as to the technique of shooting foul shots.

APPENDIX A

INTRODUCTION TO THE MENTAL PRACTICE TECHNIQUE

The subjects in this experimental group (mental practice) are to participate in the investigation of a proposed method of learning a motor skill which, in addition to being novel, should be a fascinating learning experience.

While half of the subjects engaged in this experiment will practice daily by taking actual physical shots at a basket, you will be requested to take only mental shots at an imaginary basket as outlined in the work sheet. Your part in this experiment will enable us to determine the effect of substituting mental practice for the usual physical practice in the teaching of a motor skill. Remember, you must not disclose to anyone your part in this experiment until it is finished because of the possibility that someone in the physical practice group might learn about your method and be tempted to practice it. This would completely destroy the worth of the experiment.

This mental practice technique for learning a motor skill is based on strong evidence compiled by Mr. Clark. It is his contention that if you know and understand the reasons for the particular body positions and motions involved in the execution of a particular motor skill, and are trained in these motions so that you have developed a muscular feel of them, and also a vital awareness of proper form to a point where you can visualize this form in your mind's eye, so to speak, you can actually strengthen the neural pattern for that skill by concentrated mental practice as directed by the work sheet. You are to remain motionless while doing the mental practice.

You can at once test in part the possibilities of the thought behind this experiment by doing the following: Place your hands palm up against the underside of the top of your desk, and press vigorously against it for about fifteen seconds. Now relax with arms resting on lap and palms still up. Proceed to imagine yourself lifting against the desk in the same manner. Concentrate on an imagined forceful lift. You will now note that the muscles involved in the physical effort are again tensing in much the same way as if you are actually lifting. This, in a simple way, demonstrates scientific evidence that discloses that your muscles engage in implicit or hidden (unnoticed) activity each time you think about a motor skill that you know from experience.

The subjects in this experimental (mental practice) group may well be laying the groundwork for new methods of training, not only in athletics, but in aviation, industry, and even in medicine.

APPENDIX A

"MENTAL PRACTICE" WORK SHEET

Mental Practice

1. Subject is to imagine taking a position on a foul line with careful thought being given to the proper placement of the feet and alignment of the body as follows:

   A. For the right-handed shooter, place the feet in a well-balanced position with the right foot forward (for the left-handed shooter, the left foot forward), with the toes of the left foot approximately even with the heels of the right foot, and approximately six inches to the left of the heel. Stance should be comfortable (think back to the physical practice period, and attempt to sense stance while at the same time remaining motionless) and varies somewhat with the individual. The body should be held erect but with a slight forward leaning from the waist so that the weight rests somewhat on the forward foot.

2. Subject should now imagine taking a basketball in his hands and carefully thinking about positioning them as follows: (Subject must remain motionless.)

   A. Left hand should be held under the ball with fingers well spread, palm up, and right hand with fingers well spread and tips held firmly against the back of the ball; right palm at all times facing the basket. The right elbow should be held comfortably at the side. Hands should hold ball in front of right shoulder and comfortably close to the body.

3. Subject is now to take five imaginary practice foul shots at an imaginary basket while sitting motionless. Carefully think through the release of the ball as follows:

   A. With the above points in mind, now attempt to imagine, picture in your mind's eye, yourself in proper position on an imaginary foul line for making an imaginary foul shot at an imaginary basket. Mentally dip the ball slightly forward to break the wrists for the purpose of gaining relaxation. Follow this motion instantly with a smooth-flowing upward push on the ball with both hands to a point where, if the left hand went any higher, it would cause the left shoulder to tilt upward. Remember, from this point on, it becomes strictly a one-handed shot. Be certain to visualize a leg-dip coordinated with the wristbreaking motion. Carefully visualize (sense, picture, feel) an upward vertical push on the ball (finger-tip control) that terminates at full arm extension in a wrist-snapping forward motion. Remember, the middle three fingers should push up and forward toward the target (a spot on the front of the rim) in a smooth follow-through so as to impart a slow backspin to the ball. Concentrate on finger-tip control. (Subject should attempt to sense these movements while remaining motionless.)

B. Be certain to picture in your mind a slight leg-dip and extension gracefully coordinated with a full right (left) arm extension that terminates in a smooth, relaxed, forward follow-through of the wrist and fingers at the target.

C. Subject is to remember that the eyes must be concentrated on a spot on the front (center) of the rim during the entire sequence of motions that are involved in the release of the ball toward the basket.

D. Subject will now execute 25 imaginary foul shots at about the same rate of delivery as he would if he were actually shooting. Concentrate on the sequence of positions and motions that involve the feet, body, hands, wrists, arms, and the ball while taking these mental shots. Be certain to think of yourself as shooting each shot in a perfectly arched trajectory through the center of the hoop on the basket.

APPENDIX B

I. MASTER DATA SHEET FOR SCHOOL NO. I

MASTER DATA SHEET FOR SCHOOL NO. II

MASTER DATA SHEET FOR SCHOOL NO. III

MASTER DATA SHEET FOR SCHOOL NO. IV

II. DIAGRAM FOR EQUATING SUBJECTS ON THE BASIS OF ARM STRENGTH AND INTELLIGENCE

SCHOOLS NO. I, NO. II, NO. III, NO. IV.

III. DIAGRAM FOR EQUATING SUBJECTS ON THE BASIS OF ARM STRENGTH, INTELLIGENCE, PHYSICAL PRACTICE GROUP, MENTAL PRACTICE GROUP, CATEGORY OF EXPERIENCE

<u>VARSITY</u>: SCHOOLS NO. I, NO. II, NO. III, NO. IV

<u>JR</u>. <u>VARSITY</u>: SCHOOLS NO. I, NO. II, NO. III, NO. IV.

<u>NOVICE</u>: SCHOOLS NO. I, NO. II, NO. III, NO. IV

IV. PHYSICAL PRACTICE GROUP RECORD SHEETS

SCHOOLS NO. I, NO. II, NO. III, NO. IV

V. MENTAL PRACTICE GROUP RECORD SHEETS

SCHOOLS NO. I, NO. II, NO. III, NO. IV

VI. VALUES REQUIRED FOR OBTAINING SUMS OF SQUARES AND PRODUCTS

VII. VALUES REQUIRED FOR OBTAINING THE SUMS OF SQUARES AND PRODUCTS SPECIFIED IN TABLE XXII

VIII. AN ILLUSTRATION OF HOW SUMS OF SQUARES AND PRODUCTS WERE OBTAINED.

IX. SCORES, SQUARES, AND CROSS PRODUCTS FOR ALL ARM STRENGTH X INTELLIGENCE X GROUP COMBINATIONS

X. NOTES TAKEN ON THE INTROSPECTIVE ANALYSES

APPENDIX B

TABLE X

MASTER DATA SHEET FOR SCHOOL NO. I

Subject Number	Push-ups	Pull-ups	Weight (Lbs.)	Height (Inches)	Arm Strength	I.Q.	Initial Score	Final Score
(Varsity)								
1.	35	9	162	68.5	1087	93	9	19
2.	35	6	132	68.5	890	100	9	20
3.	25	7	159	71.5	875	98	19	16
4.	20	4	185	74.	780	96	12	14
5.	25	4	150	69.	696	91	24	21
6.	20	4	167	71.8	683	99	20	16
7.	20	6	167	69.	668	110	14	13
8.	20	3	147	71.	614	105	14	9
9.	17	4	153	71.5	563	113	11	18
10.	24	4	144	64.8	536	92	17	12
11.	30	6	137	67.8	472	93	24	21
12.	10	4	160	75.5	441	98	18	16
(Jr. Varsity)								
1.	25	4	160	67.	667	90	13	13
2.	20	6	149	69.	621	120	16	15
3.	20	0	175	72.	590	125	13	13
4.	16	4	162	71.	544	120	16	12
5.	18	4	145	70.	539	112	16	13
6.	21	3	130	68.	504	111	4	10
7.	25	8	134	61.8	500	93	9	13
8.	9	4	165	74.3	400	99	16	15
9.	16	2	140	67.	378	103	13	17
10.	14	1	162	67.5	356	101	13	14
11.	14	0	139	69.5	328	113	14	14
12.	7	0	135	68.5	154	96	7	10
(Novices)								
1.	30	5	148	68.8	835	83	6	14
2.	30	9	126	66.5	745	105	11	12
3.	30	7	125	67.5	740	90	11	13
4.	30	3	140	67.5	710	100	11	12
5.	20	3	163	71.5	638	104	15	15
6.	20	4	141	69.8	572	101	7	10
7.	16	4	153	68.3	565	101	11	10
8.	16	2	133	68.	383	91	6	9
9.	10	2	165	72.	342	90	2	11
10.	15	4	133	65.	332	91	6	8
11.	5	0	170	68.	125	99	6	4
12.	5	3	101	64.8	119	115	7	7

Arm Strength = (Push-ups + Pull-ups) x $\left(\frac{\text{Weight}}{10} + \text{Height} - 60\right)$

APPENDIX B

TABLE XI

MASTER DATA SHEET FOR SCHOOL NO. II

Subject Number	Push-ups	Pull-ups	Weight (Lbs.)	Height (Inches)	Arm Strength	I.Q.	Initial Score	Final Score
(Varsity)								
1.	29	4	182	69.5	914	97	14	16
2.	34	3	162	68.	895	126	13	17
3.	30	0	174	71.5	867	108	5	17
4.	22	7	175	71.	827	108	16	17
5.	26	9	145	69.	823	114	13	16
6.	26	7	158	68.5	802	104	15	19
7.	18	0	181	75.	596	112	13	19
8.	15	6	152	73.	592	104	18	15
9.	14	3	182	71.8	506	99	12	17
10.	16	3	131	70.	439	104	13	21
11.	10	0	197	76.	357	98	13	15
12.	10	0	150	68.	230	99	18	19
(Jr. Varsity)								
1.	26	7	161	70.	860	88	5	5
2.	25	4	148	71.	748	101	8	13
3.	25	9	124	68.	692	117	10	16
4.	21	3	152	71.	629	118	8	11
5.	16	7	148	71.	593	100	10	12
6.	21	3	133	70.	559	114	14	19
7.	20	6	132	66	499	97	16	13
8.	13	4	153	71.5	491	95	15	14
9.	15	5	143	68.5	455	87	10	14
10.	16	0	113	67.8	285	124	9	9
11.	7	1	181	75.	265	101	11	11
12.	10	0	130	64.	170	107	11	14
(Novices)								
1.	35	11	185	73.	1449	97	5	13
2.	30	6	172	72.	1051	114	10	16
3.	31	6	156	71.	981	101	7	15
4.	30	0	236	69.	978	102	17	15
5.	30	4	168	69.	887	105	8	13
6.	25	5	151	71.5	798	101	7	13
7.	28	5	154	68.	771	123	17	17
8.	23	2	173	71.	758	105	11	11
9.	22	2	178	71.	691	113	8	7
10.	20	5	145	70.5	625	114	8	14
11.	19	4	145	69.8	558	106	11	18
12.	10	5	138	70.5	365	108	13	9

$$\text{Arm Strength} = (\text{Push-ups} + \text{Pull-ups}) \times \left(\frac{\text{Weight}}{10} + \text{Height} - 60\right)$$

APPENDIX B

TABLE XII

MASTER DATA SHEET FOR SCHOOL NO. III

Subject Number	Push-ups	Pull-ups	Weight (Lbs.)	Height (Inches)	Arm Strength	I.Q.	Initial Score	Final Score
(Varsity)								
1.	56	8	158	68.	1530	92	18	18
2.	37	7	174	71.	1250	123	17	20
3.	33	8	164	72.	1164	128	8	17
4.	36	2	160	71.	1064	105	14	20
5.	29	5	163	70.	901	95	18	21
6.	26	5	154	71.8	849	107	19	20
7.	27	5	155	69.	784	100	18	13
8.	20	5	152	75.8	773	104	17	17
9.	18	7	170	76.	575	93	18	18
10.	22	7	184	71.	565	100	15	19
11.	15	3	161	74.	540	100	17	20
12.	15	7	151	69.	530	100	13	22
(Jr. Varsity)								
1.	31	9	151	72.	1100	112	19	21
2.	40	11	137	65.	954	92	18	15
3.	19	1	226	76.5	782	106	10	17
4.	23	5	148	69.5	694	110	10	18
5.	26	3	144	68.	650	107	17	19
6.	15	1	167	68.5	560	95	16	18
7.	16	4	165	71.5	560	93	11	21
8.	14	4	156	74.5	543	107	18	18
9.	12	5	149	71.8	490	104	11	16
10.	16	6	139	69.	438	104	14	20
11.	17	4	116	65.5	372	111	7	17
12.	10	4	134	66.5	279	115	15	22
(Novices)								
1.	65	18	134	64.	1442	101	8	15
2.	32	11	205	69.8	1312	81	8	12
3.	40	9	162	67.	1137	78	7	7
4.	34	12	148	69.	1095	116	15	21
5.	30	3	178	68.	851	102	9	10
6.	32	5	170	69.	851	97	14	15
7.	35	2	153	65.	786	100	9	16
8.	25	6	163	69.	784	112	12	12
9.	20	2	184	74.	713	100	8	8
10.	25	7	158	66.5	704	85	7	12
11.	25	4	150	67.5	667	97	12	11
12.	20	3	142	68.5	522	107	11	16

$$\text{Arm Strength} = (\text{Push-ups} + \text{Pull-ups}) \times \left(\frac{\text{Weight}}{10} + \text{Height} - 60\right)$$

APPENDIX B

TABLE XIII

MASTER DATA SHEET FOR SCHOOL NO. IV

Subject Number	Push-ups	Pull-ups	Weight (Lbs.)	Height (Inches)	Arm Strength	I.Q.	Initial Score	Final Score
(Varsity)								
1.	40	18	164	69.	1473	112	14	19
2.	31	15	178	71.8	1359	105	16	19
3.	30	10	176	77.	1284	103	8	18
4.	40	7	185	69.	1199	103	15	18
5.	28	8	166	75.	1138	105	16	18
6.	30	13	149	69.	1114	109	16	16
7.	30	12	165	68.	1029	110	20	20
8.	28	6	163	73.5	1013	114	17	19
9.	35	7	145	69.5	984	120	20	20
10.	20	6	186	73.5	812	113	12	17
11.	22	8	152	71.	786	104	13	18
12.	18	4	162	73.	642	101	18	18
(Jr. Varsity)								
1.	35	10	160	71.5	1227	130	10	16
2.	39	7	135	69.	1260	130	17	21
3.	30	12	148	68.	959	120	16	18
4.	29	6	186	68.	931	101	14	17
5.	28	6	162	70.	891	115	6	15
6.	20	8	166	74.	857	143	12	15
7.	17	5	197	75.	763	114	13	13
8.	20	1	167	76.	687	101	8	16
9.	20	10	150	66.	630	114	9	12
10.	33	6	106	64.5	589	120	14	15
11.	20	3	143	69.	536	107	16	19
12.	7	0	142	71.	176	123	5	9
(Novices)								
1.	38	11	130	64.8	870	103	14	16
2.	30	4	126	66.5	649	100	15	15
3.	25	3	133	69.	596	106	8	18
4.	22	9	118	67.	583	95	10	11
5.	21	6	134	66.5	537	126	10	11
6.	20	6	144	64.8	499	134	6	10
7.	20	5	134	66.5	498	122	5	15
8.	32	2	108	62.5	452	120	7	14
9.	15	3	148	67.	392	87	12	14
10.	17	3	122	61.5	260	107	6	11
11.	4	0	235	74.	150	97	7	16
12.	22	6	108	64.5	122	125	6	10

$$\text{Arm Strength} = (\text{Push-ups} + \text{Pull-ups}) \times \left(\frac{\text{Weight}}{10} + \text{Height} - 60\right)$$

APPENDIX B

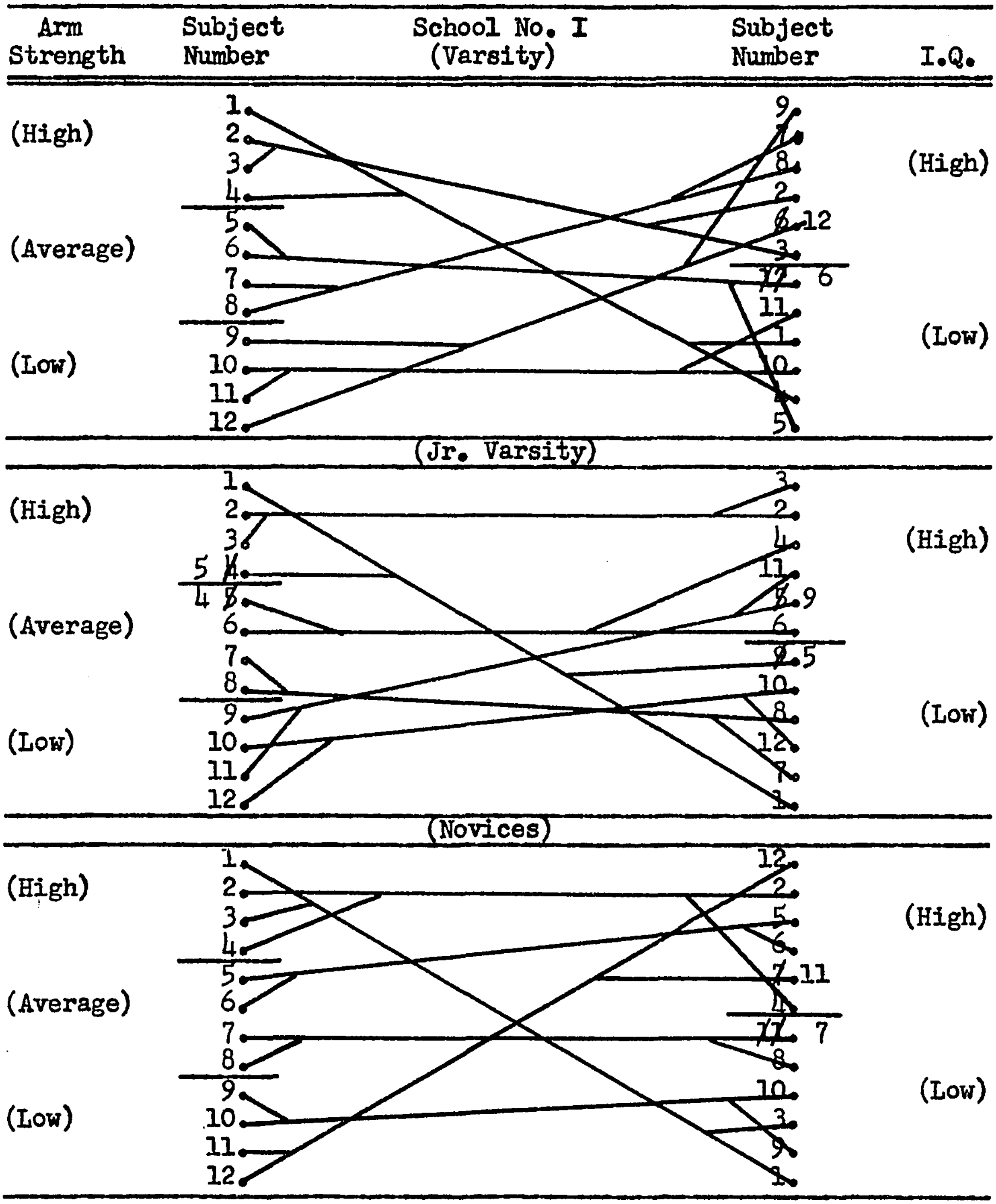


Fig. 1. Diagram for Equating Subjects on the Basis of Arm Strength and Intelligence.

Note: Subjects are arranged in descending order of magnitude of arm strength and of intelligence.

APPENDIX B

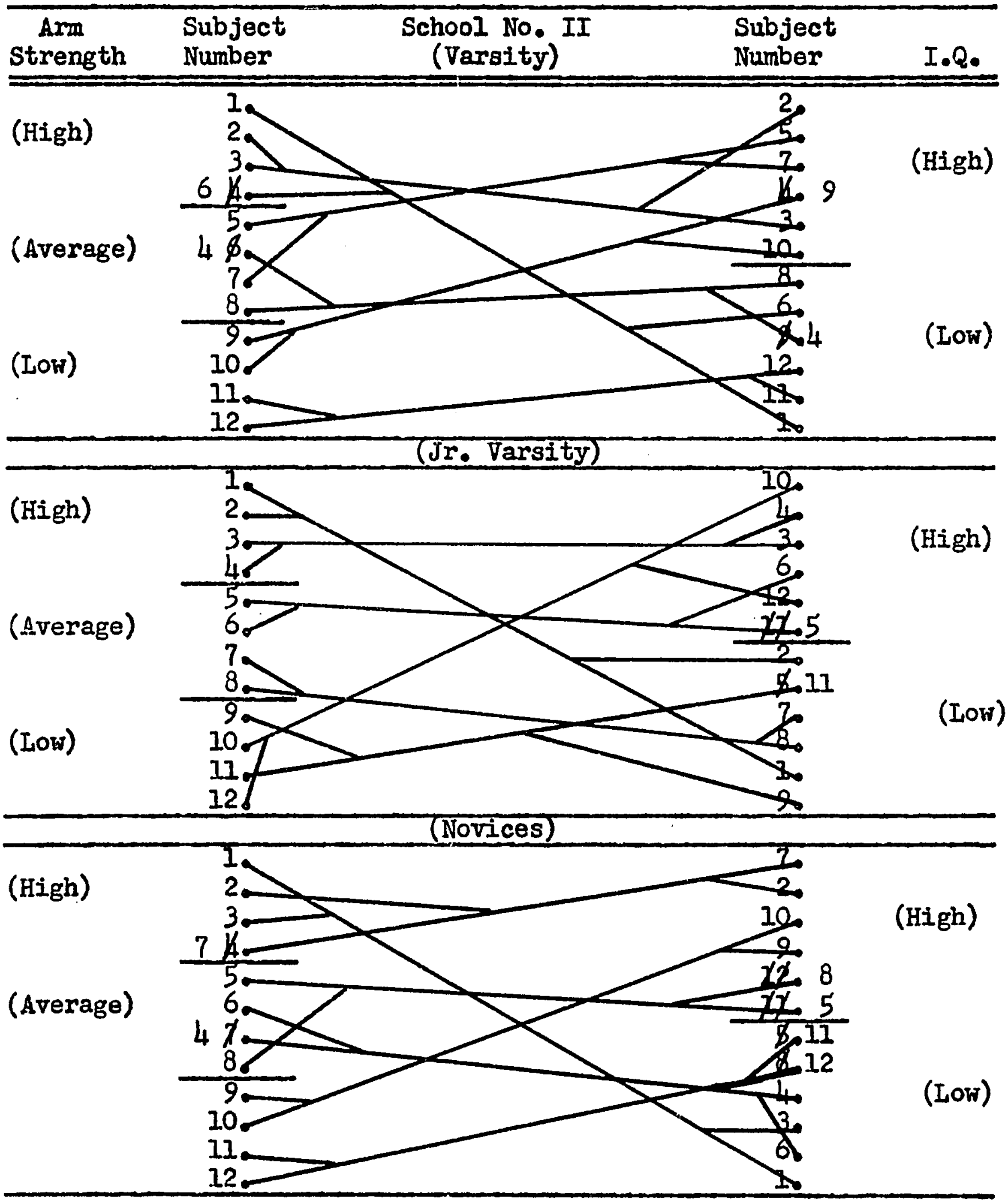


Fig. 2. Diagram for Equating Subjects on the Basis of Arm Strength and Intelligence.

Note: Subjects are arranged in descending order of magnitude of arm strength and of intelligence.

APPENDIX B

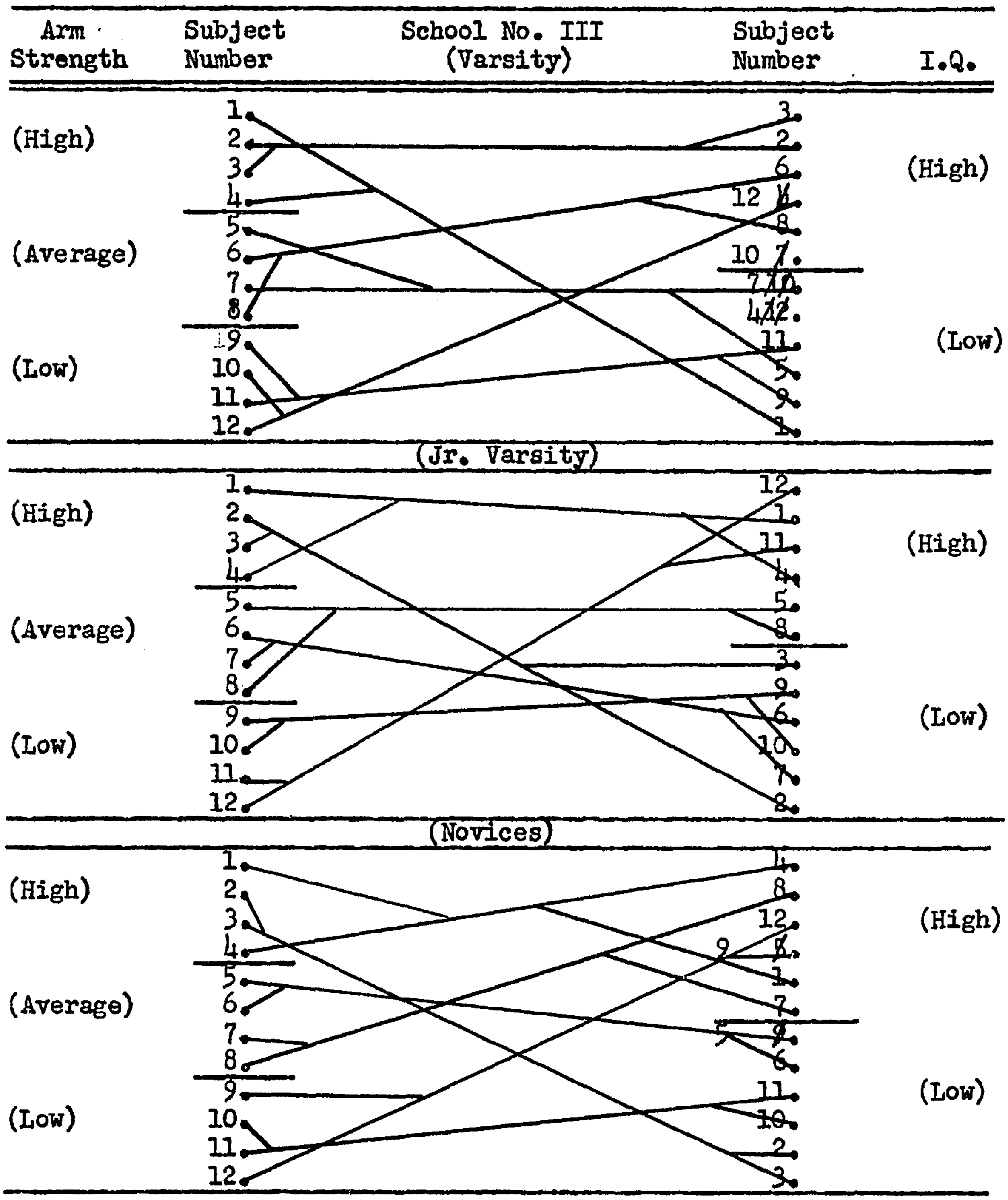


Fig. 3. Diagram for Equating Subjects on the Basis of Arm Strength and Intelligence.

Note: Subjects are arranged in descending order of magnitude of arm strength and of intelligence.

APPENDIX B

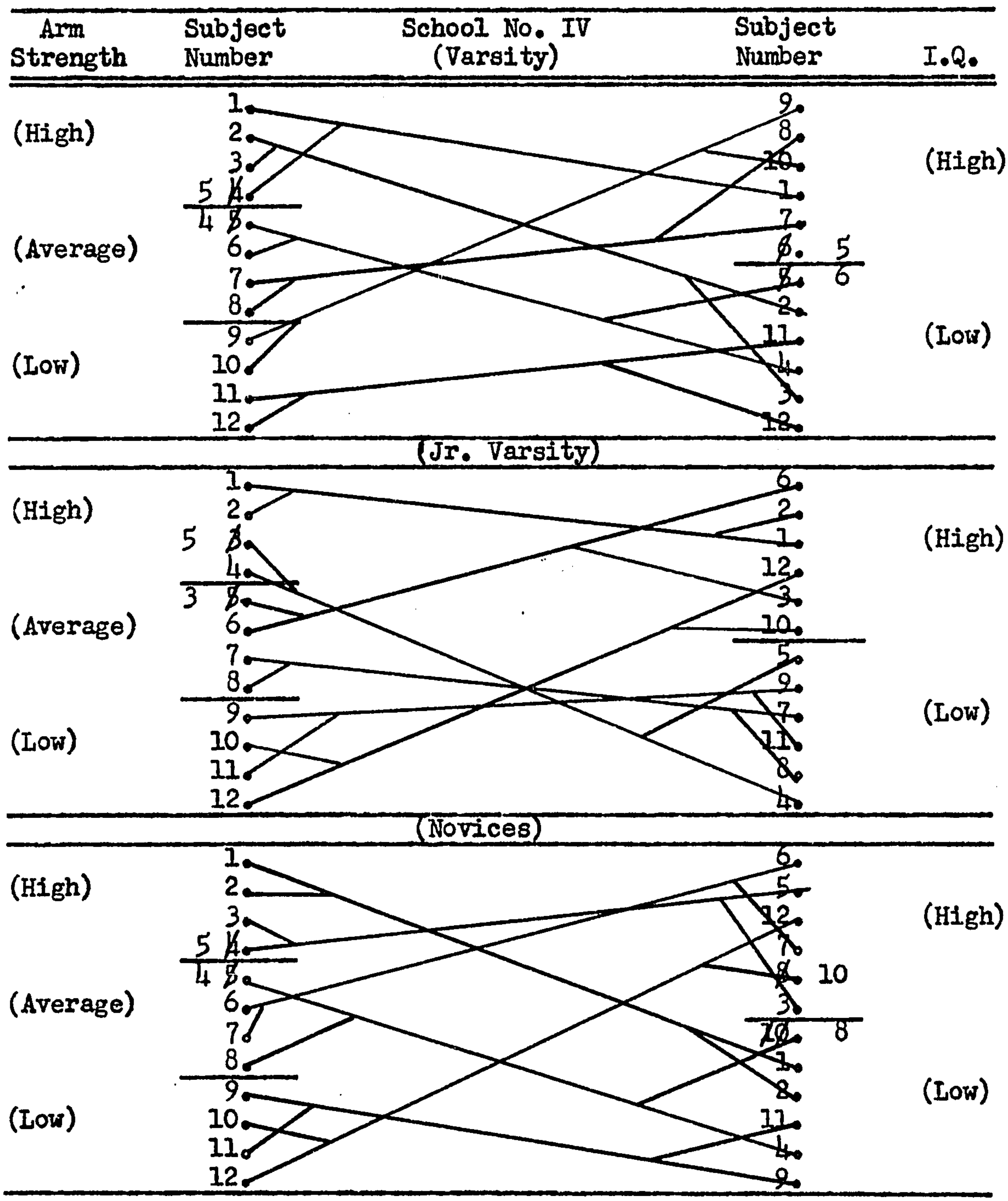


Fig. 4. Diagram for Equating Subjects on the Basis of Arm Strength and Intelligence.

Note: Subjects are arranged in descending order of magnitude of arm strength and of intelligence.

APPENDIX B

School No. I (Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 2	HH Subject No. 3
	L (Low I.Q.)	HL Subject No. 1	HL Subject No. 4
A Arm Strength (Average)	H. (High I.Q.)	AH Subject No. 7	AH Subject No. 8
	L (Low I.Q.)	AL Subject No. 5	AL Subject No. 6
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 9	LH Subject No. 12
	L (Low I.Q.)	LL Subject No. 11	LL Subject No. 10

Fig. 5. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. II (Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 3	HH Subject No. 2
	L (Low I.Q.)	HL Subject No. 6	HL Subject No. 1
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 5	AH Subject No. 7
	L (Low I.Q.)	AL Subject No. 8	AL Subject No. 4
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 9	LH Subject No. 10
	L (Low I.Q.)	LL Subject No. 12	LL Subject No. 11

Fig. 6. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. III (Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 2	HH Subject No. 3
	L (Low I.Q.)	HL Subject No. 1	HL Subject No. 4
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 8	AH Subject No. 6
	L (Low I.Q.)	AL Subject No. 7	AL Subject No. 5
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 12	LH Subject No. 10
	L (Low I.Q.)	LL Subject No. 11	LL Subject No. 9

Fig. 7. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. IV (Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 5	HH Subject No. 1
	L (Low I.Q.)	HL Subject No. 2	HL Subject No. 3
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 7	AH Subject No. 8
	L (Low I.Q.)	AL Subject No. 4	AL Subject No. 6
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 9	LH Subject No. 10
	L (Low I.Q.)	LL Subject No. 12	LL Subject No. 11

Fig. 8. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. I (Jr. Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 3	HH Subject No. 2
	L (Low I.Q.)	HL Subject No. 1	HL Subject No. 5
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 6	AH Subject No. 4
	L (Low I.Q.)	AL Subject No. 7	AL Subject No. 8
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 9	LH Subject No. 11
	L (Low I.Q.)	LL Subject No. 12	LL Subject No. 10

Fig. 9. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. II (Jr. Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 3	HH Subject No. 4
	L (Low I.Q.)	HL Subject No. 2	HL Subject No. 1
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 5	AH Subject No. 6
	L (Low I.Q.)	AL Subject No. 7	AL Subject No. 8
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 12	LH Subject No. 10
	L (Low I.Q.)	LL Subject No. 11	LL Subject No. 9

Fig. 10. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. III (Jr. Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I. Q.)	HH Subject No. 4	HH Subject No. 1
	L (Low I.Q.)	HL Subject No. 2	HL Subject No. 3
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 8	AH Subject No. 5
	L (Low I.Q.)	AL Subject No. 6	AL Subject No. 7
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 12	LH Subject No. 11
	L (Low I.Q.)	LL Subject No. 10	LL Subject No. 9

Fig. 11. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. IV (Jr. Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 2	HH Subject No. 1
	L (Low I.Q.)	HL Subject No. 4	HL Subject No. 5
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 3	AH Subject No. 6
	L (Low I.Q.)	AL Subject No. 8	AL Subject No. 7
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 10	LH Subject No. 12
	L (Low I.Q.)	LL Subject No. 11	LL Subject No. 9

Fig. 12. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. I (Novices)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 2	HH Subject No. 4
	L (Low I.Q.)	HL Subject No. 1	HL Subject No. 3
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 5	AH Subject No. 6
	L (Low I.Q.)	AL Subject No. 7	AL Subject No. 8
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 11	LH Subject No. 12
	L (Low I.Q.)	LL Subject No. 10	LL Subject No. 9

Fig. 13. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. II (Novices)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 2	HH Subject No. 7
	L (Low I.Q.)	HL Subject No. 1	HL Subject No. 3
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 5	AH Subject No. 8
	L (Low I.Q.)	AL Subject No. 6	AL Subject No. 4
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 10	LH Subject No. 9
	L (Low I.Q.)	LL Subject No. 12	LL Subject No. 11

Fig. 14. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. III (Novices)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 1	HH Subject No. 4
	L (Low I.Q.)	HL Subject No. 3	HL Subject No. 2
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 7	AH Subject No. 8
	L (Low I.Q.)	AL Subject No. 6	AL Subject No. 5
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 12	LH Subject No. 9
	L (Low I.Q.)	LL Subject No. 10	LL Subject No. 11

Fig. 15. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

School No. IV (Novices)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 3	HH Subject No. 5
	L (Low I.Q.)	HL Subject No. 2	HL Subject No. 1
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 7	AH Subject No. 6
	L (Low I.Q.)	AL Subject No. 8	AL Subject No. 4
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 10	LH Subject No. 12
	L (Low. I.Q.)	LL Subject No. 9	LL Subject No. 11

Fig. 16. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX B

TABLE XIV

PHYSICAL PRACTICE GROUP RECORD SHEET

School No. I Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity)																
2	9	11	15	18	13	14	19	11	11	a	13	12	a	15	14	20
1	9	11	11	13	11	19	11	13	13	9	12	15	9	9	9	19
7	14	15	15	12	14	11	13	13	12	17	16	a	a	19	16	13
5	24	16	16	19	17	19	22	21	17	19	19	23	a	21	20	21
9	11	15	14	7	16	9	13	14	17	18	17	14	19	13	11	18
6 10	24	22	21	19	20	18	21	21	20	21	22	22	a	18	22	21
(Jr. Varsity)																
3	13	10	10	12	a	13	14	14	15	13	7	16	a	16	a	13
1	13	16	16	8	a	16	18	16	13	15	14	12	12	16	a	13
6	4	11	11	15	a	12	11	14	14	15	15	16	11	16	17	10
7	9	10	11	9	14	7	10	13	9	8	15	10	13	14	12	13
9	13	12	12	14	12	9	7	7	14	8	10	10	5	7	11	17
12	7	11	10	15	5	12	10	9	12	15	8	11	7	11	10	10
(Novices)																
2	11	5	10	8	11	11	9	4	11	10	10	5	a	8	13	12
1	6	6	10	8	12	9	14	13	13	9	10	12	a	7	8	14
5	15	12	10	15	7	5	13	13	6	15	13	14	a	12	11	15
7	11	a	12	12	13	13	13	12	13	15	16	16	14	16	a	10
11	6	4	a	3	8	3	5	3	8	10	4	5	3	10	5	4
10	6	8	10	6	13	a	8	11	15	a	8	10	10	8	14	8

Note: The number of shots made out of 25 practice shots taken each day of the experiment are recorded.

APPENDIX B

TABLE XV

PHYSICAL PRACTICE GROUP RECORD SHEET

School No. II Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity)																
3	5	13	6	11	12	11	14	17	16	13	11	14	13	11	12	17
6	15	13	12	14	12	11	17	15	17	12	20	14	14	15	15	19
5	13	16	13	20	22	14	12	14	17	14	18	18	14	18	16	16
8	18	16	18	21	11	17	19	15	16	14	18	17	18	15	10	15
9	12	13	13	15	11	13	12	15	11	16	14	15	14	11	17	17
12	18	16	17	19	17	17	15	23	23	19	21	20	21	18	21	19
(Jr. Varsity)																
3	10	16	6	11	15	14	11	10	13	17	13	13	12	11	13	16
2	8	7	13	11	9	14	11	12	14	14	9	14	14	10	14	13
5	10	5	12	14	16	13	12	16	10	12	9	16	10	14	14	12
7	16	17	9	16	11	8	10	14	15	6	15	8	14	13	11	13
12	11	13	9	6	7	15	9	14	15	14	15	14	12	14	14	14
11	11	10	11	11	12	7	6	7	7	10	8	8	12	9	11	11
(Novices)																
2	10	9	8	12	7	14	11	13	7	14	12	9	10	14	12	16
5	8	6	9	6	9	14	11	15	11	14	7	11	9	10	10	13
6	7	11	9	6	13	8	11	11	15	11	7	9	10	7	8	13
10	8	10	8	9	14	11	13	9	9	10	8	15	9	15	12	14
12	13	13	11	11	11	11	12	6	12	7	11	11	12	11	15	9
1	5	7	5	10	13	7	5	11	11	9	13	10	12	10	9	13

Note: The number of shots made out of 25 practice shots taken each day of the experiment are recorded.

APPENDIX B

TABLE XVI

PHYSICAL PRACTICE GROUP RECORD SHEET

School No. III Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 2	17	19	19	23	19	20	22	21	19	23	22	21	23	22	22	20
1	18	18	19	20	20	22	22	20	22	20	19	20	21	22	23	18
8	17	14	19	15	16	16	14	16	16	15	18	17	16	17	18	17
7	18	18	21	21	17	16	13	12	13	10	12	9	11	12	a	13
12	13	14	19	13	16	14	15	16	15	13	16	18	16	19	20	22
11	17	17	18	17	19	19	22	16	20	17	17	21	18	15	20	20
(Jr. Varsity) 4	10	14	13	16	19	21	18	16	21	21	19	17	18	a	19	18
2	18	15	15	15	13	17	15	17	20	18	16	16	14	16	a	15
8	18	18	16	16	15	15	13	13	19	14	18	18	18	19	19	18
6	16	14	12	14	12	16	17	16	15	14	14	14	16	15	19	18
12	15	16	18	17	17	17	17	17	20	16	16	17	21	16	19	22
10	14	13	14	16	14	14	13	16	16	13	9	17	14	11	16	20
(Novices) 1	8	7	9	12	6	9	7	9	14	9	6	7	12	14	a	15
3	7	3	7	5	6	4	8	10	8	9	11	5	9	5	11	7
7	9	13	14	14	14	16	14	a	13	14	18	11	13	7	15	16
6	14	16	13	17	15	16	17	13	10	18	12	13	14	12	9	15
12	11	14	14	7	10	15	8	12	13	11	12	13	6	a	a	16
10	7	7	7	8	9	10	12	13	15	11	9	12	15	15	14	12

Note: The number of shots made out of 25 practice shots taken each day of the experiment are recorded.

a = absence.

APPENDIX B

TABLE XVII

PHYSICAL PRACTICE GROUP RECORD SHEET

School No. IV Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity)																
5	16	20	19	17	14	18	17	17	17	19	18	18	19	17	a	18
2	16	19	19	18	17	19	17	19	18	15	20	19	20	18	a	19
7	20	17	9	16	19	21	16	22	20	22	21	20	21	19	a	20
4	15	18	17	18	19	17	18	19	20	19	17	18	18	19	a	18
9	20	19	20	18	21	22	20	22	16	19	20	22	20	20	a	20
12	18	19	13	16	15	17	18	18	16	19	18	16	19	19	a	18
(Jr. Varsity)																
2	17	10	19	19	18	15	18	20	19	18	19	18	21	20	a	21
4	14	20	18	19	14	18	17	18	20	19	17	19	19	17	a	17
3	16	14	17	19	17	16	17	17	18	15	18	20	19	17	a	18
8	8	9	8	10	11	11	14	10	7	11	13	10	8	8	a	16
10	14	14	18	13	18	17	16	15	15	20	18	14	18	17	a	15
11	16	19	21	17	17	23	7	22	17	20	19	22	20	19	a	19
(Novices)																
3	8	8	10	10	14	14	9	12	14	10	13	12	16	11	a	18
2	15	13	16	15	14	15	13	13	14	16	15	14	16	15	a	15
7	5	5	10	13	12	10	13	14	15	12	15	13	15	16	a	15
8	7	7	13	12	10	12	13	8	11	10	13	14	9	10	a	14
10	6	5	8	7	10	12	13	8	6	8	7	10	9	12	a	11
9	12	8	10	11	12	13	10	12	13	9	14	10	9	8	a	14

Note: The number of shots made out of 25 practice shots taken each day of the experiment are recorded.

a = absence.

APPENDIX B

TABLE XVIII

MENTAL PRACTICE GROUP RECORD SHEET

School No. I Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 3	19	21	19	22	15	15	19	13	13	15	12	12	12	12	12	16
4	12	18	18	8	12	14	12	12	14	14	13	13	15	14	12	14
8	14	18	14	18	17	14	13	13	15	14	15	9	a	a	10	9
6	20	21	17	18	17	19	15	14	13	14	13	13	10	10	10	16
12	18	18	11	12	11	10	a	10	11	10	9	10	a	a	9	16
10	17	18	22	17	17	14	11	10	11	10	a	12	11	13	a	12
(Jr. Varsity) 2	16	18	15	16	14	13	11	10	11	9	9	9	9	10	9	15
5	16	18	19	19	9	6	5	10	12	10	12	14	12	12	11	13
4	16	18	11	13	11	11	9	10	8	9	9	10	8	10	9	12
8	16	18	12	8	12	a	13	14	10	9	10	9	8	10	10	15
11	14	18	19	19	10	4	6	7	13	12	8	10	10	13	9	14
10	13	18	21	16	14	12	13	10	11	10	13	11	9	10	10	14
(Novices) 4	11	18	8	11	10	10	10	9	10	11	9	10	11	12	a	12
3	11	18	8	8	11	12	12	11	11	12	12	15	12	10	11	13
6	7	18	13	10	10	13	10	10	14	11	10	10	a	10	13	10
8	6	18	10	7	6	7	12	7	10	9	10	8	7	9	10	9
12	7	18	9	10	9	10	10	10	10	11	10	10	11	10	11	7
9	2	18	18	10	10	4	6	11	8	10	13	12	12	13	a	11

Note: Raised figures--Tuesday of first week through Friday of the third week--represent minutes of mental practice.

a = absence.

APPENDIX B

TABLE XIX

MENTAL PRACTICE GROUP RECORD SHEET

School No. II Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 2	13	9	7	8	10	7	7	9	8	10	9	9	9	10	9	17
1	14	7	8	8	7	8	8	8	8	7	8	7	8	7	8	16
7	13	6	6	7	8	7	7	7	7	6	7	7	7	7	6	19
4	16	8	12	8	7	7	7	6	6	7	7	7	7	7	7	17
10	13	10	11	10	9	9	9	9	8	8	8	8	7	8	7	21
11	13	10	9	11	10	10	9	9	9	9	9	9	9	9	9	15
(Jr. Varsity) 4	8	6	15	12	11	11	9	10	11	11	10	10	8	10	a	11
1	5	15	10	10	11	7	8	6	8	6	6	7	7	8	7	5
6	14	9	8	8	7	7	6	6	6	6	5	5	5	5	5	19
8	15	9	9	8	7	7	6	6	5	5	5	5	5	5	5	14
10	9	9	14	12	10	8	9	9	10	10	9	10	9	9	10	9
9	10	10	11	10	10	9	8	9	8	8	9	9	8	7	8	14
(Novices) 7	17	9	8	7	7	6	9	7	8	6	a	a	a	a	a	17
3	7	6	6	7	8	6	6	5	6	5	5	5	6	5	5	15
8	11	10	12	11	8	8	8	6 (Cast) *	7	8	7	7	7	7	7	11
4	17	10	14	10	10	11	11	9	8	8	8	9	10	10	9	15
9	8	15	14	9	7	7	7	9	8	7	7	7	8	8	8	7
11	11	6	12	10	7	7	9	9	8	6	7	6	a	7	6	18

Note: Raised figures--Tuesday of first week through Friday of the third week--represent minutes of mental practice.

a = absence.

*See Appendix B, pp. 181, 4d.

APPENDIX B

TABLE XX

MENTAL PRACTICE GROUP RECORD SHEET

School No. III Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 3	8	10	a	15	a	10	15	10	10	10	15	15	10	12	10	17
4	14	10	15	15	10	15	15	10	10	9	10	8	12	17	12	20
6	19	10	11	10	a	10	9	11	9	8	10	a	12	9	8	20
5	18	10	10	9	11	14	10	9	8	11	a	10	12	9	a	21
10	15	11	10	10	8	10	9	10	10	11	9	10	12	9	a	19
9	18	10	a	9	10	11	9	8	a	a	10	10	9	a	11	18
(Jr. Varsity) 1	19	10	15	12	10	12	a	9	11	10	8	12	a	9	10	21
3	10	10	15	15	15	15	17	15	15	15	15	15	15	17	a	17
5	17	10	12	17	15	14	14	10	15	12	13	10	12	15	18	19
7	11	10	22	17	18	17	15	17	16	16	15	16	15	12	13	21
11	7	10	9	15	15	15	15	13	13	15	13	15	14	10	a	17
9	11	10	10	12	10	12	10	9	10	10	15	10	12	12	15	16
(Novices) 4	15	10	9	10	11	11	10	10	9	11	10	10	10	10	11	21
2	8	10	12	15	10	11	10	10	9	11	10	10	10	10	a	12
8	12	10	19	20	20	17	14	15	16	15	15	15	15	14	10	12
5	9	10	18	10	11	12	15	12	15	15	15	15	15	15	20	10
9	8	10	15	12	13	15	11	10	12	11	13	14	8	13	9	8
11	12	10	17	19	10	11	16	9	12	10	14	11	10	11	12	11

Note: Raised figures--Tuesday of first week through Friday of the third week--represent minutes of mental practice.

APPENDIX B

TABLE XXI

MENTAL PRACTICE GROUP RECORD SHEET

School No. IV Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 1	14	10	11	14	10	9	10	11	8	7	10	9	8	9	a	19
3	8	10	8	10	11	12	13	14	10	8	10	11	13	9	a	18
8	17	10	15	15	15	12	15	15	10	5	20	5	10	15	5	19
6	16	10	10	17	10	15	10	10	12	10	11	12	10	11	10	16
10	12	10	12	13	12	9	9	11	10	9	8	11	10	14	8	17
11	15	10	12	10	9	8	7	10	11	12	9	8	12	10	a	18
(Jr. Varsity) 1	10	10	10	11	15	10	12	10	15	10	12	10	7	10	11	16
5	6	10	15	20	20	10	10	17	20	16	11	13	10	14	11	15
6	12	10	8	10	9	9	10	9	8	8	9	10	8	9	8	15
7	13	10	13	12	15	10	10	10	10	13	12	10	9	8	10	13
12	5	10	11	7	8	12	10	9	7	10	11	10	7	8	7	9
9	9	10	10	15	10	10	8	8	8	8	10	10	8	9	10	12
(Novices) 5	10	10	8	7	10	11	4	10	10	9	9	8	11	10	7	11
1	14	10	11	12	14	10	9	8	14	12	10	7	5	5	a	16
6	6	10	11	12	8	9	12	11	9	8	11	12	8	10	11	10
4	10	10	10	11	9	8	7	9	10	11	12	14	13	12	9	11
12	6	10	11	12	10	9	8	10	11	12	10	7	8	9	8	10
11	7	10	7	10	8	10	9	8	12	11	10	9	10	8	a	16

Note: Raised figures--Tuesday of first week through Friday of the third week--represent minutes of mental practice.

APPENDIX B

TABLE XXII

VALUES REQUIRED FOR OBTAINING THE SUMS OF SQUARES AND PRODUCTS

SOURCE	D.F.	Σy^2	Σx^2	Σxy
Arm Strength x Intelligence x School x Class X Group	12	$a_1 - (b_{11} + b_{12} + b_{13} + b_{14} + b_{15}) + (c_{10} + c_{11} + c_{12} + c_{13} + c_{14} + c_{15} + c_{16} + c_{17} + c_{18} + c_{19}) - (d_{10} + d_{11} + d_{12} + d_{13} + d_{14} + d_{15} + d_{16} + d_{17} + d_{18} + d_{19}) + (e_{11} + e_{12} + e_{13} + e_{14} + e_{15}) - f_1$	$a_2 - (b_{21} + b_{22} + b_{23} + b_{24} + b_{25}) + (c_{20} + c_{21} + c_{22} + c_{23} + x_{24} + c_{25} + c_{26} + c_{27} + c_{28} + c_{29}) + (d_{20} + d_{21} + d_{22} + d_{23} + d_{24} + d_{25} + d_{26} + d_{27} + d_{28} + d_{29}) + (e_{21} + e_{22} + e_{23} + e_{24} + e_{25}) - f_2$	$a_3 - (b_{31} + b_{32} + b_{33} + b_{34} + b_{35}) + (c_{30} + c_{31} + c_{32} + c_{33} + c_{34} + c_{35} + c_{36} + c_{37} + c_{38} + c_{39}) - (d_{30} + d_{31} + d_{32} + d_{33} + d_{34} + d_{35} + d_{36} + d_{37} + d_{38} + d_{39}) + (e_{31} + e_{32} + e_{33} + e_{34} + e_{35}) - f_3$
Arm Strength x Intelligence x School x Class	12	$b_{13} - (c_{10} + c_{12} + c_{13} + c_{16}) + (d_{10} + d_{11} + d_{13} + d_{14} + d_{15} + d_{17}) - (e_{11} + e_{12} + e_{14} + e_{15}) + f_1$	$b_{23} - (c_{20} + c_{22} + c_{23} + c_{26}) + (d_{20} + d_{21} + d_{23} + d_{24} + d_{25} + d_{27}) - (e_{21} + e_{22} + e_{24} + e_{25}) + f_2$	$b_{33} - (c_{30} + c_{32} + c_{33} + c_{36}) + (d_{30} + d_{31} + d_{33} + d_{34} + d_{35} + d_{37}) - (e_{31} + e_{32} + e_{34} + e_{35}) + f_3$

TABLE XXII (Continued)

SOURCE	D.F.	Σy^2	Σx^2	Σxy
Arm Strength x Intelligence x School x Group	6	$b_{12} - (c_{10} + c_{11} + c_{14} + c_{17}) + (d_{10} + d_{11} + d_{12} + d_{14} + d_{16} + d_{18}) - (e_{11} + e_{12} + e_{13} + e_{15}) + f_1$	$b_{22} - (c_{20} + c_{21} + c_{24} + c_{27}) + (d_{20} + d_{21} + d_{22} + d_{24} + d_{26} + d_{28}) - (e_{21} + e_{22} + e_{23} + e_{25}) + f_2$	$b_{32} - (c_{30} + c_{31} + c_{34} + c_{37}) + (d_{30} + d_{31} + d_{32} + d_{34} + d_{36} + d_{38}) - (e_{31} + e_{32} + e_{33} + e_{35}) + f_3$
Arm Strength x Intelligence x Class X Group	4	$b_{11} - (c_{11} + c_{12} + c_{15} + c_{18}) + (d_{10} + d_{12} + d_{13} + d_{15} + d_{16} + d_{19}) - (e_{11} + e_{12} + e_{13} + e_{14}) + f_1$	$b_{21} - (c_{21} + c_{22} + c_{25} + c_{28} + (d_{20} + d_{22} + d_{23} + d_{25} + d_{26} + d_{29}) - (e_{21} + e_{22} + e_{23} + e_{24}) + f_2$	$b_{31} - (c_{31} + c_{32} + c_{35} + c_{38} + (d_{30} + d_{22} + d_{23} + d_{35} + d_{36} + d_{39}) - (e_{31} + e_{32} + e_{33} + e_{34}) + f_3$
Arm Strength x School x Class x Group	12	$b_{14} - (c_{13} + c_{14} + c_{15} + c_{19}) + (d_{11} + d_{12} + d_{13} + d_{17} + d_{18} + d_{19}) - (e_{11} + e_{13} + e_{14} + e_{15}) + f_1$	$b_{24} - (c_{23} + c_{24} + c_{25} + c_{29}) + (d_{21} + d_{22} + d_{23} + d_{27} + d_{28} + d_{29}) - (e_{21} + e_{23} + e_{24} + e_{25}) + f_2$	$b_{34} - (c_{33} + c_{34} + c_{35} + c_{39}) + (d_{31} + d_{32} + d_{33} + d_{37} + d_{38} + d_{39}) - (e_{31} + e_{33} + e_{34} + e_{35}) + f_1$
Intelligence x School x Class x Group	6	$b_{15} - (c_{16} + c_{17} + c_{18} + c_{19}) + (d_{14} + d_{15} + d_{16} + d_{17} + d_{18} + d_{19}) - (e_{12} + e_{13} + e_{14} + e_{15}) + f_1$	$b_{25} - (c_{26} + c_{27} + c_{28} + c_{29}) + (d_{24} + d_{25} + d_{26} + d_{27} + d_{28} + d_{29}) - (e_{22} + e_{23} + e_{24} + e_{25}) + f_2$	$b_{35} - (c_{36} + c_{37} + c_{38} + c_{39}) + (d_{34} + d_{35} + d_{36} + d_{37} + d_{38} + d_{39}) - (e_{32} + e_{33} + e_{34} + e_{35}) + f_3$

TABLE XXII (Continued

SOURCE	D.F.	Σy^2	Σx^2	Σxy
Arm Strength x Intelligence x School	6	$c_{10}-(d_{10}+d_{11}+d_{14})+(e_{11}+e_{12}+e_{15})-f_1$	$c_{20}-(d_{20}+d_{21}+d_{24})+(e_{21}+e_{22}+e_{25})-f_2$	$c_{30}-(d_{30}+d_{31}+d_{34}+(e_{31}+e_{32}+e_{35})-f_3$
Arm Strength x Intelligence x Class	4	$c_{12}-(d_{10}+d_{13}+d_{15})+(e_{11}+e_{12}+e_{14})-f_1$	$c_{22}-(d_{20}+d_{23}+d_{25})+e_{21}+e_{22}+e_{24})-f_2$	$c_{32}-(d_{30}+d_{33}+d_{35})+e_{31}+e_{32}+e_{35})-f_3$
Arm Strength x Intelligence x Group	2	$c_{11}-(d_{10}+d_{12}+d_{16})+(e_{11}+e_{12}+e_{13})-f_1$	$c_{21}-(d_{20}+d_{22}+d_{26})+(e_{21}+e_{22}+e_{33})-f_2$	$c_{31}-(d_{30}+d_{32}+d_{36})+(e_{31}+e_{32}+e_{33})-f_3$
Arm Strength x School x Class	12	$c_{13}-(d_{11}+d_{13}+d_{17})+(e_{11}+e_{14}+e_{15})-f_1$	$c_{23}-(d_{21}+d_{23}+d_{27})+(e_{21}+e_{24}+e_{25})-f_2$	$c_{33}-(d_{31}+d_{33}+d_{37})+(e_{31}+e_{34}+e_{35})-f_3$
Arm Strength x School x Group	6	$c_{14}-(d_{11}+d_{12}+d_{18})+(e_{11}+e_{13}+e_{15})-f_1$	$c_{24}-(d_{21}+d_{22}+d_{28})+(e_{21}+e_{23}+e_{25})-f_2$	$c_{34}-(d_{31}+d_{32}+d_{38})+e_{31}+e_{33}+e_{35})-f_3$
Arm Strength x Class x Group	4	$c_{15}-(d_{12}+d_{13}+d_{19})+(e_{11}+e_{13}+e_{14})-f_1$	$c_{25}-(d_{22}+d_{23}+d_{29})+(e_{21}+e_{23}+e_{24})-f_2$	$c_{35}-(d_{32}+d_{33}+d_{39})+(e_{31}+e_{33}+e_{34})-f_3$
Intelligence x School x Class	6	$c_{16}-(d_{14}+d_{15}+d_{17})+(e_{12}+e_{14}+e_{15})-f_1$	$c_{26}-(d_{24}+d_{25}+d_{27})+(e_{22}+e_{24}+e_{25})-f_2$	$c_{36}-(d_{34}+d_{35}+d_{37})+(e_{32}+e_{34}+e_{35})-f_3$

TABLE XXII (Continued)

SOURCE	D.F.	Σy^2	Σx^2	Σxy
Intelligence x School x Group	3	$c_{17}-(d_{14}+d_{16}+d_{18})$ + $(e_{12}+e_{13}+e_{15})$ - f_1	$c_{27}-(d_{24}+d_{26}+d_{28})$ + $(e_{22}+e_{23}+e_{25})$ - f_2	$c_{37}-(d_{34}+d_{36}+d_{38})$ + $(e_{32}+e_{33}+e_{35})$ - f_3
Intelligence x Class x Group	2	$c_{18}-(d_{15}+d_{16}+d_{19})$ + $(e_{12}+e_{13}+e_{14})$ - f_1	$c_{28}-(d_{25}+d_{26}+d_{29})$ + $(e_{22}+e_{23}+e_{24})$ - f_2	$c_{38}-(d_{35}+d_{36}+d_{39})$ + $(e_{32}+e_{33}+e_{34})$ - f_3
School x Class X Group	6	$c_{19}-(d_{17}+d_{18}+d_{19})$ + $(e_{13}+e_{14}+e_{15})$ - f_1	$c_{29}-(d_{27}+d_{28}+d_{29})$ + $(e_{23}+e_{24}+e_{25})$ - f_2	$c_{39}-(d_{37}+d_{38}+d_{39})$ + $(e_{33}+e_{34}+e_{35})$ - f_3
Arm Strength x Intelligence	2	$d_{10}-(e_{11}+e_{12})$ + f_1	$d_{20}-(e_{21}+e_{22})$ + f_2	$d_{30}-(e_{31}+e_{32})$ + f_3
Arm Strength x School	6	$d_{11}-(e_{11}+e_{15})$ + f_1	$d_{21}-(e_{21}+e_{25})$+ f_2	$d_{31}-(e_{31}+e_{35})$ + f_3
Arm Strength x Class	4	$d_{13}-(e_{11}+e_{14})$ + f_1	$d_{23}-(e_{21}+e_{24})$ + f_2	$d_{33}-(e_{31}+e_{32})$ + f_3
Arm Strength x Group	2	$d_{12}-(e_{11}+e_{13})$ + f_1	$d_{22}-(e_{21}+e_{23})$ + f_2	$d_{32}-(e_{31}+e_{33})$ + f_3
Intelligence x School	3	$d_{14}-(e_{11}+e_{15})$ + f_1	$d_{24}-(e_{22}+e_{25})$ + f_2	$d_{34}-(e_{32}+e_{35})$ + f_3
Intelligence x Class	2	$d_{15}-(e_{12}+e_{14})$ + f_1	$d_{25}-(e_{22}+e_{24})$ + f_2	$d_{35}-(e_{32}+e_{34})$ + f_3
Intelligence x Group	1	$d_{16}-(e_{12}+e_{13})$ + f_1	$d_{26}-(e_{22}+e_{23})$ + f_2	$d_{36}-(e_{32}+e_{33})$ + f_3
School x Class	6	$d_{17}-(e_{14}+e_{15})$ + f_1	$d_{27}-(e_{24}+e_{25})$ + f_2	$d_{37}-(e_{34}+e_{35})$ + f_3

TABLE XXII (Continued)

SOURCE	D.F.	Σy^2	Σx^2	Σxy
School x Group	3	$d_{18}-(e_{13}+e_{15}) + f_1$	$d_{28}-(e_{23}+e_{25}) + f_2$	$d_{38}-(e_{33}+e_{35}) + f_3$
Class x Group	2	$d_{19}-(e_{13}+e_{14}) + f_1$	$d_{29}-(e_{23}+e_{24}) + f_2$	$d_{39}-(e_{33}+e_{34}) + f_3$
Arm Strength (a)	2	$e_{11} - f_1$	$e_{21} - f_2$	$e_{31} - f_3$
Intelligence (i)	1	$e_{12} - f_1$	$e_{22} - f_2$	$e_{32} - f_3$
School (s)	3	$e_{15} - f_1$	$e_{25} - f_2$	$e_{35} - f_3$
Class (c)	2	$e_{14} - f_1$	$e_{24} - f_2$	$e_{34} - f_3$
Group (g)	1	$e_{13} - f_1$	$e_{23} - f_2$	$e_{33} - f_3$
Total	143	$a_1 - f_1$	$a_2 - f_2$	$a_3 - f_3$

APPENDIX B

TABLE XXIII

VALUES REQUIRED FOR OBTAINING THE SUMS OF SQUARES AND PRODUCTS SPECIFIED IN TABLE XXII

Let

a = arm strength = 1, 2, 3.

i = intelligence = 1, 2.

g = group = 1, 2.

c = class = 1, 2, 3.

s = schools = 1, 2, 3, 4.

then, let

$$A_1 = \sum_a \sum_i \sum_g \sum_c \sum_s y^2_{aigcs} = 34{,}728$$

$$A_2 = \sum_a \sum_i \sum_g \sum_c \sum_s x^2_{aigcs} = 24{,}371$$

$$A_3 = \sum_a \sum_i \sum_g \sum_c \sum_s (x_{aigcs} y_{aigcs}) = 27{,}950$$

$$B_{11} = \sum_a \sum_i \sum_g \sum_c \left[\frac{(\sum_s y_{aigcs})^2}{4} \right] = 33{,}667$$

$$B_{12} = \sum_a \sum_i \sum_g \sum_s \left[\frac{(\sum_c y_{aigcs})^2}{3} \right] = 33{,}257$$

$$B_{13} = \sum_a \sum_i \sum_c \sum_s \left[\frac{(\sum_g y_{aigcs})^2}{2} \right] = 34{,}187$$

TABLE XXIII (Continued)

$$B_{14} = \sum_a \sum_g \sum_c \sum_s \left[\frac{(\sum_i y_{aigcs})^2}{2} \right] = 34,231$$

$$B_{15} = \sum_i \sum_g \sum_c \sum_s \left[\frac{(\sum_a y_{aigcs})^2}{3} \right] = 33,969$$

$$B_{21} = \sum_a \sum_i \sum_g \sum_c \left[\frac{(\sum_s x_{aigcs})^2}{4} \right] = 22,939$$

$$B_{22} = \sum_a \sum_i \sum_g \sum_s \left[\frac{(\sum_c x_{aigcs})^2}{3} \right] = 22,228$$

$$B_{23} = \sum_a \sum_i \sum_c \sum_s \left[\frac{(\sum_g x_{aigcs})^2}{2} \right] = 23,430$$

$$B_{24} = \sum_a \sum_g \sum_c \sum_s \left[\frac{(\sum_i x_{aigcs})^2}{2} \right] = 23,566$$

$$B_{25} = \sum_i \sum_g \sum_c \sum_s \left[\frac{(\sum_a x_{aigcs})^2}{3} \right] = 23,195$$

$$B_{31} = \sum_a \sum_i \sum_g \sum_c \left[\frac{(\sum_s x_{aigcs})\ )\sum_s y_{aigcs})}{4} \right] = 27,449$$

$$B_{32} = \sum_a \sum_i \sum_g \sum_s \left[\frac{(\sum_c x_{aigcs})\ (\sum_c y_{aigcs})}{3} \right] = 26,736$$

$$B_{33} = \sum_a \sum_i \sum_c \sum_s \left[\frac{(\sum_g x_{aigcs})\ (\sum_g y_{aigcs})}{2} \right] = 27,684$$

$$B_{34} = \sum_a \sum_g \sum_c \sum_s \left[\frac{(\sum_i x_{aigcs})\ (\sum_i y_{aigcs})}{2} \right] = 27,686$$

TABLE XXIII (Continued)

$$B_{35} = \sum_i \sum_g \sum_c \sum_s \left[\frac{(\sum_a x_{aigcs})\ (\sum_a y_{aigcs})}{3} \right] = 27,561$$

$$C_{11} = \sum_a \sum_i \sum_g \left[\frac{(\sum_c \sum_s y_{aigcs})^2}{12} \right] = 32,771$$

$$C_{12} = \sum_a \sum_i \sum_c \left[\frac{(\sum_g \sum_s y_{aigcs})^2}{8} \right] = 33,495$$

$$C_{15} = \sum_a \sum_g \sum_c \left[\frac{(\sum_i \sum_s y_{aigcs})^2}{8} \right] = 33,500$$

$$C_{18} = \sum_i \sum_g \sum_c \left[\frac{(\sum_a \sum_s y_{aigcs})^2}{12} \right] = 33,347$$

$$C_{10} = \sum_a \sum_i \sum_s \left[\frac{(\sum_g \sum_c y_{aigcs})^2}{6} \right] = 33,062$$

$$C_{14} = \sum_a \sum_g \sum_s \left[\frac{(\sum_i \sum_c y_{aigcs})^2}{6} \right] = 33,104$$

$$C_{17} = \sum_i \sum_g \sum_s \left[\frac{(\sum_a \sum_c y_{aigcs})^2}{9} \right] = 33,005$$

$$C_{13} = \sum_a \sum_c \sum_s \left[\frac{(\sum_i \sum_g y_{aigcs})^2}{4} \right] = 33,883$$

$$C_{16} = \sum_i \sum_c \sum_s \left[\frac{(\sum_a \sum_g y_{aigcs})^2}{6} \right] = 33,750$$

TABLE XXIII (Continued)

$$C_{19} = \sum_g \sum_c \sum_s \left[\frac{\left(\sum_a \sum_i y_{aigcs}\right)^2}{6} \right] = 33{,}808$$

$$C_{21} = \sum_a \sum_i \sum_g \left[\frac{\left(\sum_c \sum_s y_{aigcs}\right)^2}{12} \right] = 21{,}786 + \tfrac{1}{2}$$

$$C_{22} = \sum_a \sum_i \sum_c \left[\frac{\left(\sum_g \sum_s x_{aigcs}\right)^2}{8} \right] = 22{,}755$$

$$C_{25} = \sum_a \sum_g \sum_c \left[\frac{\left(\sum_i \sum_s x_{aigcs}\right)^2}{8} \right] = 22{,}761$$

$$C_{28} = \sum_i \sum_g \sum_c \left[\frac{\left(\sum_a \sum_s x_{aigcs}\right)^2}{12} \right] = 22{,}546$$

$$C_{20} = \sum_a \sum_i \sum_s \left[\frac{\left(\sum_g \sum_c x_{aigcs}\right)^2}{6} \right] = 21{,}879$$

$$C_{24} = \sum_a \sum_g \sum_s \left[\frac{\left(\sum_i \sum_c x_{aigcs}\right)^2}{6} \right] = 21{,}986$$

$$C_{27} = \sum_i \sum_g \sum_s \left[\frac{\left(\sum_a \sum_c x_{aigcs}\right)^2}{9} \right] = 21{,}807$$

$$C_{23} = \sum_a \sum_c \sum_s \left[\frac{\left(\sum_i \sum_g x_{aigcs}\right)^2}{4} \right] = 22{,}988$$

$$C_{26} = \sum_i \sum_c \sum_s \left[\frac{\left(\sum_a \sum_g x_{aigcs}\right)^2}{\text{[illegible]}} \right] = 22{,}785$$

TABLE XXIII (Continued)

$$C_{29} = \sum_g \sum_c \sum_s \left[\frac{(\sum_a \sum_i x_{aigcs})^2}{6} \right] = 22,871$$

$$C_{31} = \sum_a \sum_i \sum_g \left[\frac{(\sum_c \sum_s x_{aigcs})(\sum_c \sum_s y_{aigcs})}{12} \right] = 26,595$$

$$C_{32} = \sum_a \sum_i \sum_c \left[\frac{(\sum_g \sum_s x_{aigcs})(\sum_g \sum_s y_{aigcs})}{8} \right] = 27,340$$

$$C_{35} = \sum_a \sum_g \sum_c \left[\frac{(\sum_i \sum_s x_{aigcs})(\sum_i \sum_s y_{aigcs})}{8} \right] = 27,700$$

$$C_{38} = \sum_i \sum_g \sum_c \left[\frac{(\sum_a \sum_s x_{aigcs})(\sum_a \sum_s y_{aigcs})}{12} \right] = 27,298$$

$$C_{30} = \sum_a \sum_i \sum_s \left[\frac{(\sum_g \sum_c x_{aigcs})(\sum_g \sum_c y_{aigcs})}{6} \right] = 26,682$$

$$C_{34} = \sum_a \sum_g \sum_s \left[\frac{(\sum_i \sum_c x_{aigcs})(\sum_i \sum_c y_{aigcs})}{6} \right] = 26,682$$

$$C_{37} = \sum_i \sum_g \sum_s \left[\frac{(\sum_a \sum_c x_{aigcs})(\sum_a \sum_c y_{aigcs})}{9} \right] = 26,660$$

$$C_{33} = \sum_a \sum_c \sum_s \left[\frac{(\sum_i \sum_g x_{aigcs})(\sum_i \sum_g y_{aigcs})}{4} \right] = 27,528$$

$$C_{36} = \sum_i \sum_c \sum_s \left[\frac{(\sum_a \sum_g x_{aigcs})(\sum_a \sum_g y_{aigcs})}{6} \right] = 27,448$$

TABLE XXIII (Continued)

$$C_{39} = \sum_g \sum_c \sum_s \left[\frac{\left(\sum_a \sum_i x_{aigcs}\right)\left(\sum_a \sum_i y_{aigcs}\right)}{6} \right] = 27,502$$

$$D_{10} = \sum_a \sum_i \left[\frac{\left(\sum_g \sum_c \sum_s y_{aigcs}\right)^2}{24} \right] = 32,717$$

$$D_{12} = \sum_a \sum_g \left[\frac{\left(\sum_i \sum_c \sum_s y_{aigcs}\right)^2}{24} \right] = 32,717$$

$$D_{13} = \sum_a \sum_c \left[\frac{\left(\sum_i \sum_g \sum_s y_{aigcs}\right)^2}{16} \right] = 33,377$$

$$D_{11} = \sum_a \sum_s \left[\frac{\left(\sum_i \sum_g \sum_c y_{aigcs}\right)^2}{12} \right] = 32,939$$

$$D_{16} = \sum_i \sum_g \left[\frac{\left(\sum_a \sum_c \sum_s y_{aigcs}\right)^2}{36} \right] = 32,684$$

$$D_{15} = \sum_i \sum_c \left[\frac{\left(\sum_a \sum_g \sum_s y_{aigcs}\right)^2}{24} \right] = 33,286$$

$$D_{14} = \sum_i \sum_s \left[\frac{\left(\sum_a \sum_g \sum_c y_{aigcs}\right)^2}{18} \right] = 32,919$$

$$D_{18} = \sum_g \sum_s \left[\frac{\left(\sum_a \sum_i \sum_c y_{aigcs}\right)^2}{18} \right] = 32,953$$

$$D_{19} = \sum_g \sum_c \left[\frac{\left(\sum_a \sum_i \sum_s y_{aigcs}\right)^2}{24} \right] = 33,307$$

TABLE XXIII (Continued)

$$D_{17} = \sum_{c}\sum_{s} \left[\frac{(\sum_{a}\sum_{i}\sum_{g} y_{aigcs})^2}{12} \right] = 33,647$$

$$D_{20} = \sum_{a}\sum_{i} \left[\frac{(\sum_{g}\sum_{c}\sum_{s} x_{aigcs})^2}{24} \right] = 21,698$$

$$D_{22} = \sum_{a}\sum_{g} \left[\frac{(\sum_{i}\sum_{c}\sum_{s} x_{aigcs})^2}{24} \right] = 21,698$$

$$D_{23} = \sum_{a}\sum_{c} \left[\frac{(\sum_{i}\sum_{g}\sum_{s} x_{aigcs})^2}{16} \right] = 22,660$$

$$D_{21} = \sum_{a}\sum_{s} \left[\frac{(\sum_{i}\sum_{g}\sum_{c} x_{aigcs})^2}{12} \right] = 21,770$$

$$D_{26} = \sum_{i}\sum_{g} \left[\frac{(\sum_{a}\sum_{c}\sum_{s} x_{aigcs})^2}{36} \right] = 21,611$$

$$D_{25} = \sum_{i}\sum_{c} \left[\frac{(\sum_{a}\sum_{g}\sum_{s} x_{aigcs})^2}{24} \right] = 22,492$$

$$D_{24} = \sum_{i}\sum_{s} \left[\frac{(\sum_{a}\sum_{g}\sum_{c} x_{aigcs})^2}{18} \right] = 21,658$$

$$D_{28} = \sum_{g}\sum_{s} \left[\frac{(\sum_{a}\sum_{i}\sum_{c} x_{aigcs})^2}{18} \right] = 21,765$$

$$D_{29} = \sum_{g}\sum_{c} \left[\frac{(\sum_{a}\sum_{i}\sum_{s} x_{aigcs})^2}{24} \right] + 22,460$$

TABLE XXIII (Continued)

$$D_{27} = \sum_{c}\sum_{s} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g} x_{aigcs}\right)^2}{12} \right] = 22,582$$

$$D_{30} = \sum_{a}\sum_{i} \left[\frac{\left(\sum_{g}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{g}\sum_{c}\sum_{s} y_{aigcs}\right)}{24} \right] = 26,566$$

$$D_{32} = \sum_{a}\sum_{g} \left[\frac{\left(\sum_{i}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{i}\sum_{c}\sum_{s} y_{aigcs}\right)}{24} \right] = 26,566$$

$$D_{33} = \sum_{a}\sum_{c} \left[\frac{\left(\sum_{i}\sum_{g}\sum_{s} x_{aigcs}\right)\left(\sum_{i}\sum_{g}\sum_{s} y_{aigcs}\right)}{16} \right] = 27,325$$

$$D_{31} = \sum_{a}\sum_{s} \left[\frac{\left(\sum_{i}\sum_{g}\sum_{c} x_{aigcs}\right)\left(\sum_{i}\sum_{g}\sum_{c} y_{aigcs}\right)}{12} \right] = 26,632$$

$$D_{36} = \sum_{i}\sum_{g} \left[\frac{\left(\sum_{a}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{c}\sum_{s} y_{aigcs}\right)}{36} \right] = 26,540$$

$$D_{35} = \sum_{i}\sum_{c} \left[\frac{\left(\sum_{a}\sum_{g}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{g}\sum_{s} y_{aigcs}\right)}{24} \right] = 27,275$$

$$D_{34} = \sum_{i}\sum_{s} \left[\frac{\left(\sum_{a}\sum_{g}\sum_{c} x_{aigcs}\right)\left(\sum_{a}\sum_{g}\sum_{c} y_{aigcs}\right)}{18} \right] = 26,618$$

$$D_{38} = \sum_{g}\sum_{s} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{c} x_{aigcs}\right)\left(\sum_{a}\sum_{i}\sum_{c} y_{aigcs}\right)}{18} \right] = 26,666$$

$$D_{39} = \sum_{g}\sum_{c} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{i}\sum_{s} y_{aigcs}\right)}{24} \right] = 27,293$$

TABLE XXIII (Continued)

$$D_{37} = \sum_c \sum_s \left[\frac{(\sum_a \sum_i \sum_g x_{aigcs})(\sum_a \sum_i \sum_g y_{aigcs})}{12} \right] = 27{,}424$$

$$E_{11} = \sum_a \left[\frac{(\sum_i \sum_g \sum_c \sum_s y_{aigcs})^2}{48} \right] = 32{,}672$$

$$E_{12} = \sum_i \left[\frac{(\sum_a \sum_g \sum_c \sum_s y_{aigcs})^2}{72} \right] = 32{,}643$$

$$E_{13} = \sum_g \left[\frac{(\sum_a \sum_i \sum_c \sum_s y_{aigcs})^2}{72} \right] = 32{,}674$$

$$E_{14} = \sum_c \left[\frac{(\sum_a \sum_i \sum_g \sum_s y_{aigcs})^2}{48} \right] = 33{,}272$$

$$E_{15} = \sum_s \left[\frac{(\sum_a \sum_i \sum_g \sum_c y_{aigcs})^2}{36} \right] = 32{,}882$$

$$E_{21} = \sum_a \left[\frac{(\sum_i \sum_g \sum_c \sum_s x_{aigcs})^2}{48} \right] = 21{,}661$$

$$E_{22} = \sum_i \left[\frac{(\sum_a \sum_g \sum_c \sum_s x_{aigcs})^2}{72} \right] = 21{,}590$$

$$E_{23} = \sum_g \left[\frac{(\sum_a \sum_i \sum_c \sum_s x_{aigcs})^2}{72} \right] = 21{,}588$$

$$E_{24} = \sum_c \left[\frac{(\sum_a \sum_i \sum_g \sum_s x_{aigcs})^2}{48} \right] = 22{,}437$$

TABLE XXIII (Continued

$$E_{25} = \sum_{s} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c} x_{aigcs}\right)^2}{36} \right] = 21{,}648$$

$$E_{31} = \sum_{a} \left[\frac{\left(\sum_{i}\sum_{g}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{i}\sum_{g}\sum_{c}\sum_{s} y_{aigcs}\right)}{48} \right] = 26{,}536$$

$$E_{32} = \sum_{i} \left[\frac{\left(\sum_{a}\sum_{g}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{g}\sum_{c}\sum_{s} y_{aigcs}\right)}{72} \right] = 26{,}539$$

$$E_{33} = \sum_{g} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{i}\sum_{c}\sum_{s} y_{aigcs}\right)}{72} \right] = 26{,}554$$

$$E_{34} = \sum_{c} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{i}\sum_{g}\sum_{s} y_{aigcs}\right)}{48} \right] = 27{,}276$$

$$E_{35} = \sum_{s} \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c} x_{aigcs}\right)\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c} y_{aigcs}\right)}{36} \right] = 26{,}619$$

$$F_{1} = \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c}\sum_{s} y_{aigcs}\right)^2}{144} \right] = 32{,}640$$

$$F_{2} = \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c}\sum_{s} x_{aigcs}\right)^2}{144} \right] = 21{,}585$$

$$F_{3} = \left[\frac{\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c}\sum_{s} x_{aigcs}\right)\left(\sum_{a}\sum_{i}\sum_{g}\sum_{c}\sum_{s} y_{aigcs}\right)}{144} \right] = 26{,}543$$

APPENDIX B

AN ILLUSTRATION OF HOW THE SUMS OF SQUARES AND PRODUCTS WERE OBTAINED

In order to illustrate the procedure involved in the computation of the values of A_{ij}, B_{ij}, C_{ij}, D_{ij}, E_{ij}, and F_{ij}, where $i = 1, 2, 3$; $j = 1, 2, \ldots 8, 9$; the values of C_{11}, C_{21}, and C_{31} are computed below in summation form:

$$C_{11} = \sum_a \sum_i \sum_g \left[\frac{(\sum_c \sum_s y_{aigcs})^2}{12} \right]$$

$$C_{21} = \sum_a \sum_i \sum_g \left[\frac{(\sum_c \sum_s x_{aigcs})^2}{12} \right]$$

$$C_{31} = \sum_a \sum_i \sum_g \left[\frac{(\sum_c \sum_s x_{aigcs})(\sum_c \sum_s y_{aigcs})}{12} \right]$$

then, in order to evaluate these terms, Table XXIV was prepared.

Consulting Table XXIV we see that: $C = \frac{393,254}{12} = 32,771\ 1/6$; $C_{21} = \frac{261,421}{12} = 21,785\ 1/12$; and $C_{31} = \frac{319,138}{12} = 26,594\ 5/6$. The value of 12 by which the respective sums are divided results from the fact that there are three classes (varsity, junior varsity, novice) in each of four schools ($3 \times 4 = 12$) combined in the $\Sigma\Sigma\ x$ and $\Sigma\Sigma\ y$ scores of the table.

APPENDIX B

TABLE XXIV

SCORES, SQUARES AND CROSS PRODUCTS FOR ALL ARM STRENGTH X INTELLIGENCE X GROUP COMBINATIONS

Arm Strength	Intelligence	Group	$\Sigma\Sigma x$	$(\Sigma\Sigma x)^2$	$\Sigma\Sigma y$	$(\Sigma\Sigma y)^2$	$(\Sigma\Sigma x)(\Sigma\Sigma y)$
H	α	M	160	25,600	193	37,248	30,880
		P	134	17,956	204	41,616	27,336
	β	M	125	15,625	174	30,276	21,750
		P	147	21,609	182	33,124	26,754
A	α	M	158	24,946	175	30,625	27,650
		P	148	21,904	183	33,489	27,084
	β	M	167	27,889	178	31,684	29,726
		P	164	26,896	180	32,400	29,520
L	α	M	122	14,884	154	23,716	18,788
		P	145	21,025	185	34,225	26,825
	β	M	138	19,044	175	30,625	24,150
		P	155	24,025	185	34,225	28,675
				(Total) 261,421		(Total) 393,254	(Total) 319,138

APPENDIX B

NOTES TAKEN ON THE INTROSPECTIVE ANALYSES

The basic set of questions prepared for this purpose was kept in mind, but was not used verbatim, in toto, or in sequence as a means of interrogation. Instead, the subject was asked to extemporize about his reactions to the experiment as best he could recall them. The questions referred to were injected into the conversation whenever the opportunity presented itself to use them without tending to "put words into the subject's mouth," or to draw out some point of information he did not volunteer. Terse notes were taken for purposes of evaluation. The kinds of observations and answers made have been grouped under the questions considered pertinent to them as follows:

1. What was your reaction to the experiment when it was first presented to you?

    a. Considered it important.

    b. Didn't know what to think about it. Wondered what it could be applied to.

    c. Mainly curious, but felt it must have value, although didn't know what.

    d. Just curious.

    e. Was interested. Believed the idea behind it a logical one.

    f. Doubted its possibilities, but now believe that mental practice helps to improve one's skill.

    g. Thought it a joke at first, then gradually became curious. Now confident mental practice works.

    h. Didn't know what to think of it.

    i. Didn't understand it, but thought mental practice might work.

2. Was the mental practice easy or difficult to engage in; that is, did you have any difficulty with concentration, or perhaps in mentally picturing the shooting technique?

   a. Difficult to concentrate at first, but it became progressively easier as the experiment moved along. A few of the subjects complained that adjoining gym noises disturbed concentration.

   b. Was difficult to carry out the mental practice as instructed at first, but it became progressively easier.

   c. Difficult to concentrate on twenty-five consecutive mental practice foul shots.

   d. Could visualize the shooting form, but had difficulty for a few days visualizing the basket.

   e. Difficulty visualizing the shooting form, but could visualize the basket. Ability to visualize the shooting form became progressively easier.

   f. Could visualize the shooting form, but couldn't imagine the spot on the rim, or the ball going into the basket. One subject used an actual spot on the wall for a few days because he could not visualize an imaginary spot on the rim of the basket. Said this enabled him to develop the ability to do so.

   g. No difficulty concentrating, or visualizing shooting form and basket.

   h. Difficult to visualize shooting form and a spot on the basket at the same time. Tended to concentrate on one or the other.

   i. Couldn't consistently visualize spot on the rim.

   j. Couldn't sense motion of arms for about a week.

   k. At first, mentally pictured shoulder action as awkward and incorrect to a point that was disturbing. Shoulder actually got a little lame, felt heavy as if a weight was hanging there. However, after about one week, was able to perceive entire process with a feeling of confidence. (Reported by one subject only.)

   l. Could imagine the shooting technique only from the perspective of a second person watching from the side of the shooting area. After considerable effort for a few days, came to visualize shooting form from the perspective of self. (Two subjects reported this hallucination.)

m. Had difficulty concentrating, and especially in visualizing the basket. Mental image of basket would tilt down so could look in it. By considerable concentration could cause imaginary basket to tilt back to normal position. However, on returning attention to visualizing shooting form, basket would tilt down again. The hallucination of the tilting basket disappeared after about one week of mental practice, but then a new hallucination occurred for three days: when concentrating on basket, had feeling of rising bodily over the basket and dunking the ball through it. Ball appeared to go through the rim as if there were no net on it. Ball didn't slow up. During the third week, came to visualize the entire process with little difficulty (Reported by one subject only.)

3. Did you notice any change in your ability to visualize, imagine, or picture the shooting form in your mind's eye?

   a. Became progressively easier. Had no difficulty after the first week. (This was the most general statement made by the mental practice group subjects showing an improvement between the Initial Score and the Final Score.)

4. Did you experience any unusual thoughts, sensations, or hallucinations during mental practice?

   a. Right arm kept tensing during mental practice, right leg sometimes. Left arm and leg tensed together slightly sometimes. Got the feeling after about one week of mental practice that "I could really make them." (Several subjects gave the same type of report.)

   b. After a few days had sensation as if actually shooting baskets.

   c. Gained confidence, as experiment progressed, that he was improving in the ability to make foul shots.

   d. One mental practice subject broke the index finger of shooting hand during the first week of the experiment. A cast immobilized the entire hand. The case projected beyond the tip of broken index finger. Subject continued mental practice with enthusiasm, and attempted to take his final test shots in spite of the projecting cast. His introspective report disclosed that he felt as if he had been shooting regularly; that he had developed a better shooting form, and that he believed he would have shown considerable improvement if he had not broken his finger. He made only one basket, but all the other attempts were near misses that hit on the front of the rim, or passed just beneath it. The projection of the cast was curved in such a way that it apparently caused the undershooting. During the subject's initial score attempts, his misses were widely scattered so the evidence suggests that he probably would have shown considerable improvement barring the accident. In view of this consideration, he was assigned a final score equal to his initial score. No improvement could be properly indicated in the statistics, but it was felt that no loss should be suffered either in view of the evidence presented.

e. One subject mentally experimented with several wrist actions.

f. Would suddenly become conscious of hands moving as if handling the ball, and "coming up" with it as if to shoot. This was reported by several subjects. One subject reported that for two days of the third week, ball kept sticking in the net. He also reported considerable nervousness while on the actual foul line to take final test shots--even "broke out in a sweat." Considered his initial test score as "extremely lucky," referring to self as a "lousy shot." His final test score was 9. He reported that he felt that the mental practice had given him a better knowledge of how to shoot. Sensed mistakes as shot left hand. It is suggested that a strong emotional factor was operating in this case.

g. Right arm became lame after every practice session for the first week. This report was made by several subjects. All seemed certain that it was the result of mental practice and not some physical activity. A few cases even reported the right leg becoming lame also. It was noted that such reactions occurred with subjects who had considerable difficulty at first in visualizing the shooting technique, but at the same time, carried out the instructions with intensity. These particular subjects also generally appeared more emotional about the experiment. (A check was made as to their intelligence test scores. They ranged from average to low. The limited number involved does not allow any conclusions.)

h. One subject had difficulty during the last week of mental practice recalling the physical "feel" of that part of the shooting form referred to in the instructions as a <u>wrist-snapping forward motion of the fingertips</u>. Wondered if he had mentally pictured basket at the proper distance from the imaginary foul line because of the fact that the first few final test shots "all fell way short." This subject had no previous basketball experience.

i. One subject reported the unusual hallucination of mentally attempting to bounce the ball preparatory to shooting only to imagine that it would not bounce; that it stuck to the floor. This disturbed him to a point where he could not successfully visualize the shooting technique. He stated that if he visualized shooting without first bouncing the ball he avoided the difficulty and could visualize the technique with a fair degree of facility. An emotional factor is strongly in evidence in this case.

j. Another subject also had difficulty as a result of imagining bouncing the ball preliminary to shooting it. Reported imagining bouncing the ball and catching it in rapid succession. Had great difficulty stopping the hallucination of bouncing the ball so he could visualize completing the shot. This subject reported difficulty with concentration. He appeared to have a poor conception of the shooting form at the end of the experiment. Could not sense mistakes that were causing him to miss. Appeared weak in perceptual ability.

k. One subject reported visualizing ball going into a basket sans net. Ball would disappear then come plummeting back "out of nowhere" and hit him in the abdomen. This hallucination kept recurring for two weeks of the experiment. He never did get to visualize net on basket. A faculty member reported that during the previous basketball season, this subject, although a good floor shot, would experience unexpected lapses in shooting skill during a game when he would miss simple shots by a wide margin. Strong emotional factors appear a possibility; also weak perceptual ability.

l. Another subject also had difficulty in visualizing the shooting technique. He reported that instead of arching in a normal trajectory, his imaginary shots would go way out to the left then swerve back into the basket. Had the impulse to shoot as soon as he had the imaginary ball in his hands. "Couldn't hold it." This impulse continued throughout the experiment, and was observable when he took the final test shots in that he shot the instant he had the ball in his hands; no time being taken to get set, aim, and shoot as the average person does. He reported that the shooting form felt awkward.

5. Did you experience monotony at any time during the course of the experiment?

a. No fatigue or boredom occurred during the practice sessions.

b. Mental practice became progressively more monotonous. (One subject reported that it made him sleepy.)

c. Slightly monotonous during the last week of the experiment. (A majority felt at least some monotony during the last few days.)

d. Mental practice became monotonous. Became impatient to shoot actual shots to find out if any improvement had occurred.

e. Didn't get monotonous because the experiment was so interesting.

6. Did your mind tend to wander at any time during the course of the mental practice sessions?

a. Once in a while for a few seconds only.

b. Did not wander.

c. Hard to concentrate on 25 consecutive mental practice shots. Mind would wander for a few seconds to things in general.

d. Mind wandered some during the first few practice sessions. Did not after that. It appeared that it was mostly subjects who reported that their mind wandered who either had little more than a curious interest in the experiment to begin with, or who had difficulty in visualizing the shooting technique.

7. Were you able to visualize a basket, and a spot on the rim? If so, were you able to do so in relation to a normal position on the foul line? (This latter question was introduced into the questioning after two subjects had reported that they had experienced hallucinations of observing themselves from a detached position as if they were another person watching the execution of the foul shooting.) As it turned out, no other subjects reported such an experience.

8. Were you able to imagine taking twenty-five perfectly executed foul shots? It is to be noted here that it was expected that a majority of the subjects might give affirmative answers whether they could or not because of an ego-defense reaction. This was not the case. Most of the subjects reported difficulty ranging from could imagine making only a few to could imagine making most of them. Only one subject spoke positively of being able to visualize making all twenty-five shots with ease.

a. Could picture making only a few at first, but it became progressively easier so that he felt he was making most of them by the third week of mental practice. Surprisingly, several subjects named the number of shots they imagined making out of twenty-five attempts each day. The number varied. Generally, there was a reported <u>increase in confidence with a parallel increase in imagined scores made.</u> When visualizing misses, several reported sensing the mistakes in technique that caused them just as if they were actually shooting.

b. Increasingly difficult to concentrate after approximately twelve practice shots. This was reported by one subject only.

c. Difficult to concentrate on twenty-five consecutive mental practice shots.

9. Did you experience any gain in confidence in the experiment or yourself as it progressed?

a. Felt confident he was improving.

b. Felt he was "making them." Gained confidence.

c. Got feeling he could really make them when he started actual shooting at the end of the mental practice sessions. Approached actual foul line with a feeling he "would have perfect form."

d. Felt as if actually shooting baskets.

e. Kept getting tense during mental practice. Felt he needed physical practice "to keep loose." Expressed belief that mental practice to be of any benefit must be accompanied by physical practice. This subject did not show any improvement.

f. After first week began to gain confidence in the experiment, and to feel that he was improving.

g. Had a definite feeling of improvement. Expected to make a better score on final test day.

10. What was your reaction when you approached foul line to take final test shots after having not handled a ball for three weeks?

a. Ball "felt natural in hands, and more so than before."

b. Felt as if he had been shooting every day. Confident he could score well.

c. Ball felt natural when first picked up. Felt shooting form was a new and improved one.

d. Knew just how to shoot correctly for the first time.

e. Definite feeling of improvement. Could sense misses as ball left fingers, and knew why misses occurred. Mentally made corrections in preparation for next shot.

f. Felt relaxed and confident.

g. Nervous at first, but settled down after five warmups because of a sudden new feeling of confidence.

h. Sensed good wrist action for the first time. Definite shooting form. Formerly felt as if shooting with a stiff-armed action. Was more confident in shooting ability.

i. Felt tight. Could not loosen up, but still felt he had better shooting form. Was more confident in shooting ability.

j. Confident he had new and better shooting form. Formerly shot by "hope-and-pray" method.

k. One subject felt "all tied up" during all final test shots. Couldn't tell why he was missing. Shooting stance felt better, but couldn't get finger action so it felt correct.

l. Felt uncomfortable at first, but loosened up and felt good after about ten shots. Was better able to keep eye on basket. Had better follow-through action. Realized mistakes enough so was able to correct most of them.

m. Recognized mistakes, but realized that he started pressing to correct them.

n. More confidence in shooting ability.

o. Felt much more confident. "Used to feel real clumsy."

p. Felt awkward at first, but ended up by feeling form had improved.

q. No special feelings. Only curious as to how well he would shoot. Only a few such reports. Most subjects reported feelings of excitement and even "pressure" during final test shooting.

r. Uneasy at first but confidence developed rapidly while shooting test shots.

11. Do you feel that the mental practice technique has helped you?

a. With the exception of two subjects, most reported definite feelings of improvement. The most noticeable thing observed in relation to this question was the fact that a majority became surprisingly acute in sensing when they made mistakes that caused misses, and that they knew just what to do to correct them.

12. Did the introductory training period help you?

a. Practically all subjects reported that their initial scores were better than what they formerly had been accustomed to shooting.

b. As a result of the instruction "knew just what to do for the first time."

c. Instruction especially helped to keep eyes on the target. Was apparently just shooting at the whole basket before.

d. Simple analogies were apparently especially helpful to a majority of the subjects.

APPENDIX C (SUPPLEMENTARY STUDIES)

I. A GRAPH OF THE EFFECT OF VERBAL INSTRUCTION ON THE LEARNING CURVES OF TWO GROUPS AS BASED ON THE CUMULATIVE ARITHMETIC MEANS OF HIGH AND LOW SCORES IN SHOOTING FOUL SHOTS.

II. MASTER DATA SHEET FOR SCHOOL NO. V.

III. DIAGRAM FOR EQUATING SUBJECTS.(SCHOOL NO. V) ON THE BASIS OF ARM STRENGTH AND INTELLIGENCE.

IV. DIAGRAM FOR EQUATING SUBJECTS (SCHOOL NO. V) ON THE BASIS OF ARM STRENGTH, INTELLIGENCE, PHYSICAL PRACTICE GROUP, MENTAL PRACTICE GROUP, CATEGORY OF EXPERIENCE (VARSITY, JUNIOR VARSITY, NOVICE).

V. PHYSICAL PRACTICE GROUP RECORD SHEET FOR SCHOOL NO. V.

VI. MENTAL PRACTICE GROUP RECORD SHEET FOR SCHOOL NO. V.

VII. THE TOTAL OF THE INITIAL SCORES OF THE THREE EXPERIENCE CATEGORIES (SCHOOL NO. V) AS BASED ON 300 SHOT ATTEMPTS BY EACH CATEGORY.

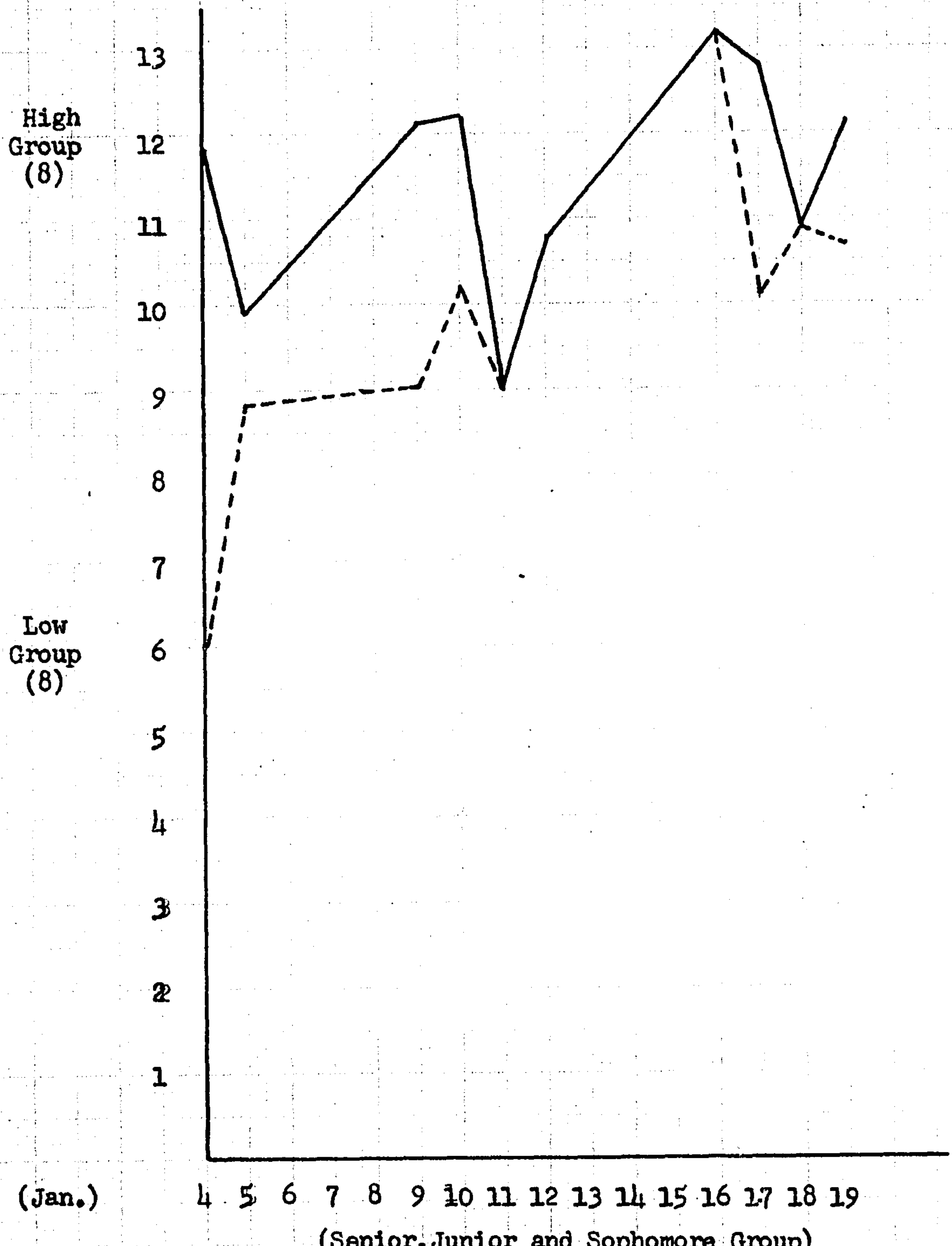
VIII. IMPROVEMENT OF THE PHYSICAL PRACTICE GROUPS (SCHOOL NO. V) IN TERMS OF BASKETS AND PER CENTS.

IX. IMPROVEMENT OF THE MENTAL PRACTICE GROUPS (SCHOOL NO. V) IN TERMS OF BASKETS AND PER CENTS.

X. TIME PATTERNS SUGGESTED AS A BASIS FOR FUTURE RESEARCH IN DETERMINING THE EFFECTS OF PHYSICAL PRACTICE, MENTAL PRACTICE, AND INTERPOLATED TIME WHEN APPLIED IN VARIOUS COMBINATIONS IN THE DEVELOPMENT OF MOTOR SKILL.

XI. NUMBER OF BASKETS GAINED FOR SUBJECTS WITH INITIAL SCORES OF 13 OR BELOW, AND 14 OR ABOVE.

XII. ANALYSIS OF IMPROVEMENT OF THE MENTAL AND PHYSICAL PRACTICE GROUPS IN TERMS OF INITIAL AND "ADJUSTED" MEAN SCORES.



Note: The cumulative arithmetic mean of the foul shots made out of 25 taken each day by each subject are indicated for both the high and low groups.

Fig.17. A Graph of the Effect of Verbal Instruction on the Learning Curves of Two Groups as Based on the Cumulative Arithmetic Means of High and Low Scores in Shooting Foul Shots.

APPENDIX C

TABLE XXV

MASTER DATA SHEET FOR SCHOOL NO. V

Subject Number	Push-ups	Pull-ups	Weight (Lbs.)	Height (Inches)	Arm Strength	I.Q.	Initial Score	Final Score
(Varsity)								
1.	45	4	178	74	1717	131	18	22
2.	30	7	154	73	1051	92	16	18
3.	30	9	155	71	1014	130	15	19
4.	33	10	138	69	980	95	15	22
5.	22	4	158	75	801	96	20	22
6.	25	7	145	70	784	100	18	21
7.	25	6	147	70	766	101	17	19
8.	12	3	184	73	471	100	19	19
9.	13	4	155	72	468	129	14	19
10.	15	3	137	69	409	114	20	23
11.	11	3	152	70	353	103	12	21
12.	10	3	142	72	341	104	15	22
(Jr. Varsity)								
1.	34	5	138	69	889	101	4	10
2.	21	5	185	72	793	102	18	16.
3.	15	5	160	73	580	107	12	19
4.	13	4	161	72	478	96	14	16
5.	10	8	165	70	477	119	16	19
6.	10	4	190	75	476	106	11	20
7.	16	3	160	70	468	100	17	21
8.	9	4	168	77	439	94	10	17
9.	22	6	152	68	418	106	11	24
10.	20	5	125	64	400	101	14	15
11.	15	3	125	67	351	108	12	16
12.	12	4	141	67	348	106	22	22
(Novices)								
1.	22	4	162	71	707	103	17	19
2.	16	7	155	69	613	105	15	18
3.	19	1	152	70	504	104	Drop-out	
4.	13	3	168	73	477	98	12	19
5.	16	3	154	69	464	108	6	21
6.	9	3	174	72	353	100	12	17
7.	9	2	150	77	347	114	11	15
8.	12	3	145	68	338	117	15	20
9.	11	3	120	66	252	108	16	17
10.	10	4	140	70	236	113	8	15
11.	5	3	161	71	217	111	14	16
12.	8	4	120	65	204	106	5	12

Arm Strength = (Push-ups + Pull-ups) x $\frac{\text{Weight}}{10}$ + Height - 60)

APPENDIX C

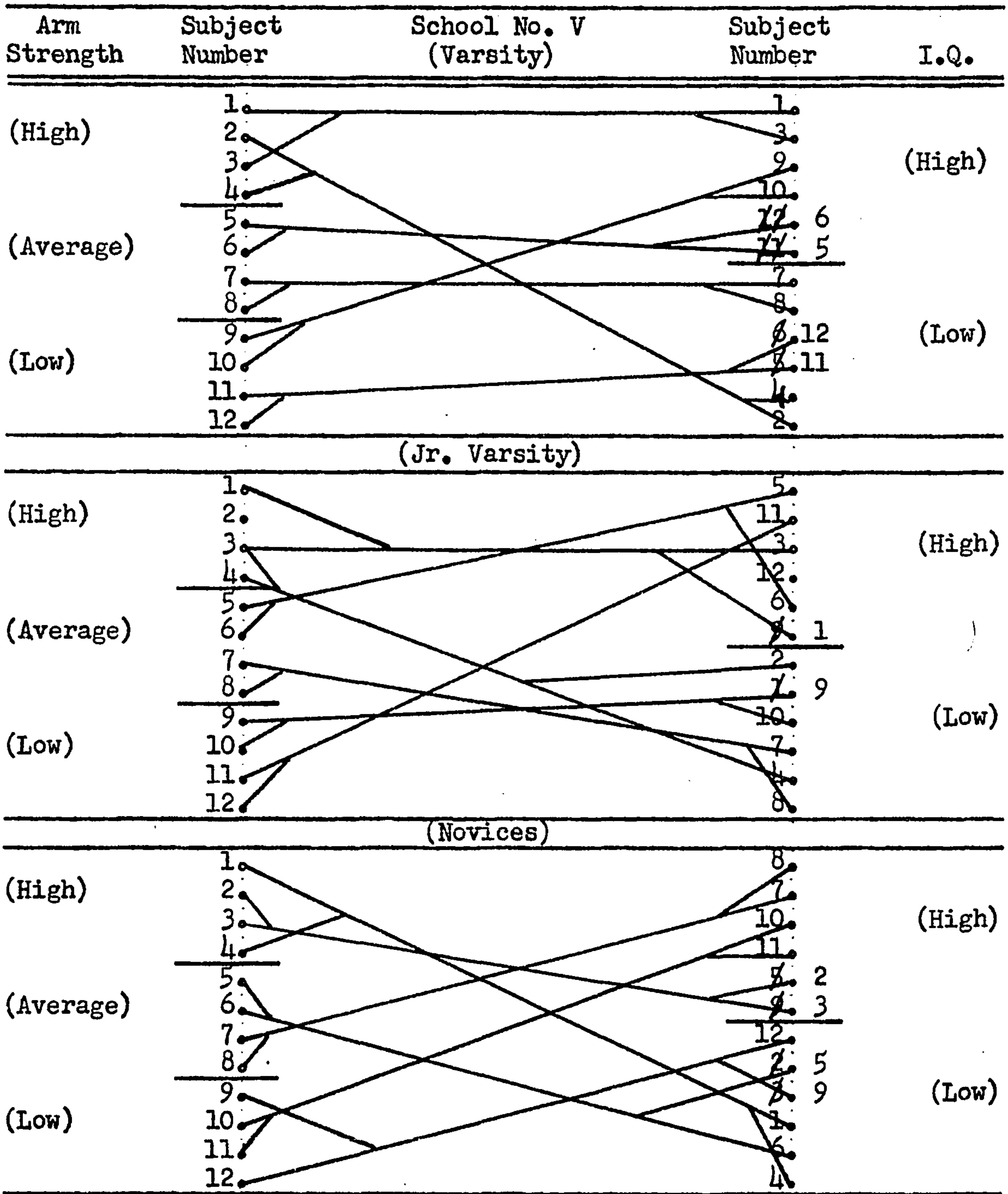


Fig. 18. Diagram for Equating Subjects on the Basis of Arm Strength and Intelligence.

Note: Subjects are arranged in descending order of magnitude of arm strength and of intelligence.

APPENDIX C

School No. V (Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 1	HH Subject No. 3
	L (Low I.Q.)	HL Subject No. 4	HL Subject No. 2
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 6	AH Subject No. 5
	L (Low I.Q.	AH Subject No. 8	AH Subject No. 7
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 9	LH Subject No. 10
	L (Low I.Q.)	LL Subject No. 12	LL Subject No. 11

Fig. 19. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX C

School No. V (Jr. Varsity)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 3	HH Subject No. 1
	L (Low I.Q.)	HL Subject No. 2	HL Subject No. 4
A Arm Strength (Average)	H (High I.Q.)	AH Subject No. 5	AH Subject No. 6
	L (Low I.Q.)	AL Subject No. 8	AL Subject No. 7
L Arm Strength (Low)	H (High I.Q.)	LH Subject No. 12	LH Subject No. 11
	L (Low I.Q.)	LL Subject No. 9	LL Subject No. 10

Fig. 20. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX C

School No. V (Novices)		Physical Practice Group	Mental Practice Group
H Arm Strength (High)	H (High I.Q.)	HH Subject No. 2	HH Subject No. 3
	L (Low I.Q.)	HL Subject No. 4	HL Subject No. 1
A Arm Strength (Average)	A (High I.Q.)	AH Subject No. 8	AH Subject No. 7
	L (Low I.Q.)	AL Subject No. 6	AL Subject No. 5
L Arm Strength	H (High I.Q.)	LH Subject No. 10	LH Subject No. 11
	L (Low.I.Q.)	LL Subject No. 12	LL Subject No. 9

Fig. 21. Diagram for Equating Subjects on the Basis of Arm Strength, Intelligence, Physical Practice Group, Mental Practice Group, Category of Experience.

APPENDIX C

TABLE XXVI

PHYSICAL PRACTICE GROUP RECORD SHEET

School No. V Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 1	18	16	17	13	21	19	18	20	21	21	18	15	20	22	22	22
4	15	16	18	13	16	19	18	18	15	20	18	18	18	18	21	22
6	18	14	18	14	17	18	18	17	16	18	17	19	20	21	12	21
8	19	18	17	19	19	17	18	18	17	16	18	19	18	19	17	19
9	14	17	15	17	16	15	16	17	21	21	21	20	19	20	19	19
12	15	20	18	21	19	20	17	16	18	17	20	22	20	22	22	22
(Jr. Varsity) 3	12	13	9	12	19	17	15	20	12	14	13	14	14	16	17	19
2	18	18	17	17	14	19	19	18	16	16	17	19	17	18	19	16
5	16	23	12	22	17	19	17	19	19	21	16	17	18	18	18	19
8	10	12	6	8	10	11	12	14	12	12	15	13	12	16	16	17
12	22	20	21	18	19	19	21	19	21	22	18	21	20	21	22	22
9	11	18	15	19	20	20	18	19	17	16	16	14	18	19	19	24
(Novices) 2	15	13	14	16	17	16	17	15	15	15	17	17	18	19	19	18
4	12	14	10	14	19	17	15	16	17	16	18	16	17	17	20	19
8	15	13	19	19	19	16	23	20	22	20	21	18	16	19	19	20
6	12	12	10	17	11	12	14	13	14	15	17	16	15	16	17	17
10	8	14	13	13	10	11	11	14	16	11	13	14	13	15	16	15
12	5	6	2	5	8	7	7	9	11	12	12	6	9	5	8	12

Note: The number of shots made out of 25 practice shots taken each day of the experiment are recorded.

a = absence.

APPENDIX C

TABLE XXVII

MENTAL PRACTICE GROUP RECORD SHEET

School No. V Subject Number	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
(Varsity) 3	15	10	10	10	10	13	5	6	7	5	17	6	6	7	6	19
2	16	9	8	10	11	18	8	7	6	9	16	5	6	5	6	18
5	20	10	11	9	8	18	7	6	5	5	18	5	5	6	4	22
7	17	8	9	9	10	18	7	6	5	5	17	5	6	7	5	19
10	20	10	7	10	10	21	10	5	5	6	21	7	5	7	6	23
11	12	10	7	10	10	14	10	7	6	8	16	6	7	6	6	21
(Jr. Varsity) 1	4	7	6	8	10	11	6	7	6	8	8	7	6	7	7	10
4	14	9	8	10	9	17	8	8	8	9	12	8	8	8	7	16
6	11	9	10	8	7	13	9	10	8	7	19	7	7	5	2	20
7	17	8	9	10	8	18	8	6	5	6	22	9	6	6	6	21
11	12	8	9	10	12	14	8	7	6	5	13	7	6	6	5	16
10	14	8	8	9	9	13	8	7	7	6	11	6	6	9	7	15
(Novices) 3	Drop-out															
1	17	8	10	7	8	18	8	11	7	5	18	6	6	7	8	19
7	11	8	7	7	6	15	7	6	6	7	13	7	7	7	7	15
5	6	9	14	12	a	14	15	13	18	11	19	8	7	6	6	21
11	14	8	7	6	8	12	8	6	6	5	13	6	6	5	5	16
9	16	7	7	6	7	14	7	8	7	6	16	7	7	5	5	17

Note: Raised figures--Tuesday of first week through Friday of the third week--represent minutes of mental practice.

a = absence.

APPENDIX C

FINDINGS OF THE SPECIAL PHASE OF THE EXPERIMENT

TABLE XXVIII

THE TOTAL OF THE INITIAL SCORES OF THE THREE EXPERIENCE CATEGORIES (SCHOOL NO. V) AS BASED ON 300 SHOT ATTEMPTS BY EACH CATEGORY

School	Varsity	Jr. Varsity	Novice
No. V	199 (66.3%)	161 (53.6%)	131 (47.6%)

In comparing the initial scores of the experience categories in the special phase of the experiment with those of the four schools of the regular experiment, it is to be noted that the varsity group in School No. V had a total initial score of seven more than the highest total initial score of any of the other four schools.[1] This result was expected inasmuch as the conditions under which instruction was given were much more ideal than those under which the subjects were trained in the preceding four schools; there were no disturbances in the gymnasium that might cause distraction. The Junior Varsity of School No. V achieved the second highest total initial score of any of the schools. The Novice Group of School No. V had a higher total initial score than any of the Novice groups in the regular experiment by a margin of nine. It is to be pointed out that the generally higher scores in this special phase of the experiment may also well be a reflection of a progressive improvement in the quality of the

[1] See Table VI.

presentation of the instructional technique used coupled with a concomitant increase in confidence in expected results which may have been transmitted to the subjects by an air of confidence on the part of the author. This point is made because of the fact that a majority of the subjects in this special phase of the experiment were especially insistent that their initial scores represented a much higher average than they had formerly been able to achieve. It is to be recalled that the subjects in the regular experiment had also reported that the instructional technique used had resulted in their immediately making higher average scores than they were formerly able to achieve.

TABLE XXIX

IMPROVEMENT OF THE PHYSICAL PRACTICE GROUPS (SCHOOL NO. V) IN TERMS OF BASKETS AND PER CENTS

School	Varsity		Jr. Varsity		Novice	
	Gain/I.S.	%	Gain/I.S.	%	Gain/I.S.	%
No. V	26/99	28	28/89	31	34/67	51

Gain = Number of baskets improvement over Initial Score
I.S. = Initial Score
% = Per Cent of Improvement

A computation of the average amount of improvement of the Novice Physical Practice groups of the four schools of the regular experiment plus that of School No. V indicates an average gain of 49% in just a three-week period. Such a score suggests the great potential the instructional technique used in this experiment has for training subjects in regular physical education classes.

It is to be recalled that the Mental Practice groups in this special phase of the experiment took physical practice shots on each successive Monday for a total of two more physical practice sessions than the Mental Practice groups of the regular phases of the experiment. It may be recalled that this was done in a search for a clue as to whether or not mental practice exerted a major portion of its effect in the first week. Certainly the data of Table XXVII does not provide a basis for assuming that it did. The Varsity Mental Practice group subjects recorded total scores of 100, 102, 105, and 122 on successive Mondays; the Junior Varsity Mental Practice group subjects recorded total scores of 72, 86, 84, and 98, and the Novice Mental Practice group subjects recorded total scores of 64, 73, 79, and 88 on the same days. In other words the Varsity group improved two baskets the first week as compared to twenty during the next two weeks; the Junior Varsity group improved fourteen baskets the first week as compared to twelve during the next two, and the Novice group improved nine the first week as compared to fifteen during the last two weeks.

TABLE XXX

IMPROVEMENT OF THE MENTAL PRACTICE GROUPS
(SCHOOL NO. V) IN TERMS OF BASKETS AND PER CENTS

School	Varsity		Jr. Varsity		Novice	
	Gain/I.S.	%	Gain/I.S.	%	Gain/I.S.	%
No. V	22/100	22	26/72	35	24/64	38

Interpreting the data another way, the insertion of two physical practice sessions into the mental practice schedule of the regular experiment resulted in the Varsity Mental Practice group experiencing an average gain of 5% over the average of the equivalent groups of Schools I, II, III, IV; of 13% for the Junior Varsity, and 19% for the Novice category. Now discounting these gains resulting from the two additional physical practice sessions in the mental practice schedule, theoretically the gain from mental practice was very similar to that indicated in the regular phases of the experiment. It therefore appears that mental practice was increasingly effective as the experiment progressed. This poses the following problem: How long would mental practice have resulted in an improvement in score if the experiment had been continued indefinitely?

The author now holds the conviction that research conducted according to the time patterns of practice indicated in Table XXXI will disclose an optimum combination of physical and mental practice sessions that can be utilized to develop instructional methods far superior to those used today to develop motor skills.

APPENDIX C

TABLE XXXI

TIME PATTERNS SUGGESTED AS A BASIS FOR DETERMINING THE EFFECTS OF PHYSICAL PRACTICE, MENTAL PRACTICE, INTERPOLATED TIME

Patterns	M	T	W	TH	FR	M	T	W	TH	FR	M	T	W	TH	FR	M
4P & O	Pt	O	O	O	O	P	O	O	O	O	P	O	O	O	O	Pt
	Pt	P	P	O	O	O	O	O	O	O	O	O	O	O	O	Pt
4P & M	Pt	M	M	M	M	P	M	M	M	M	P	M	M	M	M	Pt
	Pt	P	P	M	M	M	M	M	M	M	M	M	M	M	M	Pt
7P & O	Pt	O	P	O	O	P	O	P	O	O	P	O	P	O	O	Pt
	Pt	O	O	O	P	P	O	O	O	P	P	O	O	O	P	Pt
7P & M	Pt	M	P	M	M	P	M	P	M	M	P	M	P	M	M	Pt
	Pt	M	M	M	P	P	M	M	M	P	P	M	M	M	P	Pt
10P & O	Pt	O	P	O	P	P	O	P	O	P	P	O	P	O	P	Pt
	Pt	P	P	O	O	P	P	P	O	O	P	P	P	O	O	Pt
10P & M	Pt	M	P	M	P	P	M	P	M	P	P	M	P	M	P	Pt
	Pt	P	P	M	M	P	P	P	M	M	P	P	P	M	M	Pt
LM 7P & O	Pt	O	O	O	O	P	P	O	O	O	P	P	P	O	O	Pt
EM	Pt	P	P	O	O	P	P	O	O	O	P	O	O	O	O	Pt
LM 7P & M	Pt	M	M	M	M	P	P	M	M	M	P	P	P	M	M	Pt
EM	Pt	P	P	M	M	P	P	M	M	M	P	M	M	M	M	Pt

P: Physical Practice
Pt: Physical Practice with Test Scoring
O: No Practice
M: Mental Practice
LM: Late Massing of Practice Sessions
EM: Early Massing of Practice Sessions

APPENDIX C

TABLE XXXII

NUMBER OF BASKETS GAINED FOR SUBJECTS WITH INITIAL SCORES OF 13 OR BELOW, AND 14 OR ABOVE

Class	No. of Subjects 1 - 13	Gain	Class	No. of Subjects 14 - 25	Gain
		School No. I			
Varsity	3	23	Varsity	9	-22
Jr.Varsity	5	18	Jr.Varsity	7	- 9
Novice	11	26	Novice	1	0
		School No. II			
Varsity	7	39	Varsity	5	3
Jr.Varsity	10	14	Jr.Varsity	2	- 9
Novice	9	39	Novice	3	- 3
		School No. III			
Varsity	2	18	Varsity	10	15
Jr.Varsity	5	40	Jr.Varsity	7	17
Novice	10	27	Novice	2	8
		School No. IV			
Varsity	3	20	Varsity	9	15
Jr.Varsity	7	33	Jr.Varsity	5	14
Novice	10	53	Novice	2	2

Average Number of Subjects with Initial Score of 13 or below:

Varsity = 3.75

Jr. Varsity = 6.75

Novice = 10.00

APPENDIX C

TABLE XXXIII

ADJUSTED FINAL MEANS, $\bar{Y}_a$*, FOR MENTAL AND PHYSICAL PRACTICE GROUPS WITHIN SCHOOLS AND CLASSES

School	Group	Varsity	Jr. Varsity	Novice	Total
I	M	12.20	12.75	12.14	12.37
	P	17.59	13.56	11.63	14.25
II	M	16.97	12.76	13.98	14.57
	P	16.71	13.63	14.38	14.90
III	M	18.03	18.40	12.91	16.45
	P	16.70	17.42	14.56	16.23
IV	M	17.30	14.46	13.59	15.12
	P	16.89	16.96	15.76	16.54
TOTAL:	M	16.12	14.60	13.16	14.63
	P	16.97	15.39	14.09	15.48

*Adjusted to Total Initial Score mean of 12.24.

APPENDIX C

ANALYSIS OF IMPROVEMENT OF THE MENTAL AND PHYSICAL PRACTICE GROUPS IN TERMS OF INITIAL AND "ADJUSTED" MEAN SCORES

All Means Adjusted by Highest Order Interaction Regression Coefficient

In order to perform an analysis of the adjusted means, it was first necessary to compute the values needed to adjust the mean Final Scores. This was accomplished as follows:

1. The general form of the regression coefficient "b" is the covariance $\Sigma(x - \bar{x})\ (y - \bar{y})$ divided by the variance of the Initial Score x:

$$b = \frac{\Sigma(x - \bar{x})\ (y - \bar{y})}{\Sigma(x - \bar{x})^2}$$

Substituting the value of the highest order interaction covariance, and the highest order interaction variance of the Initial Score x, into the above formula, we have:

$$b = \frac{45}{122} = .3688$$

as the value of the highest order interaction regression coefficient.

2. The Initial Score mean $\bar{x}$, the Final Score mean $\bar{y}$, and their respective "total" means, for both the "mental" and "physical" groups are computed. The subscript "m" is used to denote the "mental" group, and subscript "p" to designate the "physical" group. Thus:

$$\bar{X}_p = \frac{893}{72} = 12.40 \qquad \bar{Y}_p = \frac{1119}{72} = 15.54$$

$$\bar{X}_m = \frac{870}{72} = 12.08 \qquad \bar{Y}_m = \frac{1049}{72} = 14.57$$

$$\bar{X}_t = \frac{1763}{144} = 12.24 \qquad \bar{Y}_t = \frac{2168}{144} = 15.06$$

Table XXXIV presents the respective means:

TABLE XXXIV

TABULAR PRESENTATION OF INITIAL SCORE MEANS, FINAL SCORE MEANS, AND GAINS OF MENTAL AND PHYSICAL PRACTICE GROUPS

	N	Initial Score Mean	Final Score Mean	Gain
Mental	72	$\bar{X}_m = 12.08$	$\bar{Y}_m = 14.57$	2.49
Physical	72	$\bar{X}_p = 12.40$	$\bar{Y}_p = 15.54$	3.14
TOTAL:	144	$\bar{X}_t = 12.24$	$\bar{Y}_t = 15.06$	2.82

3. In order to find the "adjusted" Final Score mean, the following formula is used:

$$\bar{Y}_{ai} = \bar{Y}_i - b(\bar{X}_i - \bar{X}_t) \qquad \text{(where } i = m \text{ or } p)$$

substituting the values for b and $\bar{X}_t$ into the formula,

$$\bar{Y}_{ai} = \bar{Y}_i - .3688\ (\bar{X}_i - 12.24)$$

thus, for the "mental" group:

$$\bar{Y}_{am} = \bar{Y}_m - .3688\ (\bar{X}_m - 12.24)$$

$$\bar{Y}_{am} = 14.57 - .3688\ (12.08 - 12.24)$$

$$\bar{Y}_{am} = 14.57 - .3688\ (-.16) = 14.57 + .06 = 14.63$$

and, for the "physical" group:

$$\bar{Y}_{ap} = \bar{Y}_p - .3688\ (\bar{X}_p - 12.24)$$

$$\bar{Y}_{ap} = 15.54 - .3688\ (12.40 - 12.24)$$

$$\bar{Y}_{ap} = 15.54 - .3688\ (.16) = 15.54 - .06 = 15.48$$

For the "total" mean score of the groups:

$$\bar{\bar{Y}}_{at} = \bar{\bar{Y}}_t - .3688\ (\bar{\bar{X}}_t - 12.24)$$

$$\bar{\bar{Y}}_{at} = 15.06 - .3688\ (12.24 - 12.24)$$

$$\bar{\bar{Y}}_{at} = 15.06 - .3688\ (0) = 15.06$$

Presented in tabular form, we have for the "adjusted" final score mean:

TABLE XXXV

TABULAR PRESENTATION OF ADJUSTED FINAL SCORE MEANS
OF MENTAL AND PHYSICAL PRACTICE GROUPS

	N	Initial Score Mean	Adjusted Final Score Mean	Gain
Mental	72	$X_t = 12.24$	$Y_{am} = 14.63$	2.39
Physical	72	$X_t = 12.24$	$Y_{ap} = 15.48$	3.24
TOTAL:	144	$X_t = 12.24$	$Y_{at} = 15.06$	2.82

4. The t-test is applied in order to determine if there is a statistically significant difference between (a) the "adjusted" means of the "physical" and "mental" groups, and, (b) between the Initial Score means and adjusted Final Score means within the respective groups. The t-formula, corrected for "adjustment" of the Final Score mean, is: [1]

$$t = \frac{\bar{\bar{Y}}_{ap} - \bar{\bar{Y}}_{am}}{\sqrt{\bar{S}^2_{\bar{y}a}\left(\frac{1}{N_{ap}} + \frac{1}{N_{am}}\right) + \frac{(\bar{\bar{X}}_p - \bar{\bar{X}}_m)^2}{S^2_{\bar{x}}}}} \qquad (1)$$

[1] Cochran and Cox, "Experimental Designs", John Wiley & Sons, Inc., Chapman and Hall, Limited (London, 1950)

where $\bar{Y}_{ap}$ is the adjusted Final Score mean for the "physical" practice group, $\bar{Y}_{am}$ is the adjusted Final Score mean for the "mental" practice group, N_{ap} is the number of observations in the "physical" group, N_{am} is the number of observations in the "mental" group, $S^2_{\bar{x}}$ is the Initial Score variance of the highest order interaction, and $\bar{S}^2_{\bar{y}a}$ is the "adjusted" mean square of the highest order interaction in the co-variance table. The degrees of freedom used are those associated with the adjusted mean square of the highest order interaction, $\bar{S}^2_{\bar{y}a}$.

Substituting:

$$t = \frac{15.48 - 14.63}{\sqrt{3.128 \left(\frac{1}{72} + \frac{1}{72}\right) + \frac{(12.40 - 12.08)^2}{122}}}$$

$$t = \frac{5.10}{1.77} = 2.88$$

With 11 degrees of freedom (associated with $\bar{S}^2_{\bar{y}a}$) it is found from the t-table that a value of t = 2.88 would occur less than 2% of the time due to chance factors alone, and therefore we <u>reject</u> the Null Hypothesis and accept the alternative that there is a statistically significant difference between the adjusted Final Score means of the "physical" and "mental" practice groups.[1] Since the "physical" group has the higher adjusted mean, the <u>results are in favor of that group</u>.

4b. In order to test the statistical significance of the difference between the "total" Initial Score mean and the "adjusted" Final Score

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[1] Edwards, Allen L., *Statistical Methods for the Behavioral Sciences*, Rinehart and Company, Inc., New York: 1954, Table V, page 501.

mean, within the respective "mental" and "physical" groups, the values of the mean square of the Initial Score variance and the "adjusted" mean square, of the highest order interaction, are used in the t-test for correlated observations. The formula is:

$$t = \frac{\bar{Y}_{ai} - \bar{X}_t}{\sqrt{\frac{\bar{S}^2_{\bar{y}a}}{n_i} + \frac{\bar{S}^2_{\bar{x}}}{n_i} - \frac{2r\bar{S}_{\bar{y}a}\bar{S}_{\bar{x}}}{n_i}}} \quad \text{(where } i = m \text{ or } p\text{)} \qquad (2)$$

where $\bar{S}^2_{\bar{x}}$ is the mean square of the Initial Score variance, $\bar{S}^2_{\bar{y}a}$ is the adjusted mean square, both taken from the highest order interaction; while "r" is the correlation coefficient between Initial and Final Scores computed from the values associated with the highest order interaction.

Substituting in formula (2), (See Table II, Table XXXIII, and Table XXXIV for values used):

Mental Group Gain:

$$t = \frac{14.63 - 12.24}{\sqrt{\frac{3.128}{72} + \frac{10.167}{72} - \frac{2(.57)(1.768)(3.188)}{72}}}$$

$$t = \frac{2.39}{.3087} = 7.74$$

Physical Group Gain:

$$t = \frac{15.48 - 12.24}{\sqrt{\frac{3.128}{72} + \frac{10.166}{72} - \frac{2(.57)(3.128)(1.768)}{72}}}$$

$$t = \frac{3.24}{.3087} = 10.495$$

Using a conservative test by entering the t-table with 11 degrees of freedom (associated with $S^2_{\bar{y}a}$), it is found that the values of $t = 7.74$ and $t = 10.495$ would occur less than 1% of the time due to chance factors alone; therefore, we reject the respective Null Hypotheses and conclude that the gains made within the "mental" and "physical" groups are statistically significant.

In other words, when the Final Scores were adjusted to the "total" Initial Score mean of $\bar{X}_t = 12.24$, the final average number of baskets for the Mental Practice group was 14.63, and 15.48 for the Physical Practice group, or a difference of .85 of a basket in favor of the Physical Practice group. This difference arises irrespective of differences in Schools, Classes, Groups, Arm Strength, and Intelligence. Stating it another way, 72 members in the Mental Practice group gained 2.39 baskets over the "total" Initial Score. The Physical Practice group on the other hand gained 3.24 baskets.

Comparison of the adjusted means of the Physical and Mental Practice groups, found in Table XXXIII, will show that within Schools and Classes, the Mental Practice group experienced higher adjusted mean scores in five out of twelve cases.

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Positions: Aroostook State Normal School, Presque Isle, Maine (1936)--Football Coach; Aroostook Central Institute, Mars Hill, Maine (1936-1939)--Teacher-Coach; Bar Harbor High School (1939-1940)--Director of Physical Education, Teacher-Coach; Calais Jr. High School (1940-1941)--Director of Physical Education, Teacher-Coach, Director of Summer Playground; Farmington High School, Maine (1941-1943)--Director of Physical Education, Teacher-Coach; U. S. Navy (1944-1946)--Specialist in Physical Rehabilitation (Specialist First Class); Aroostook School of Commerce, Presque Isle, Maine (1947-1948)--Basketball and Baseball Coach; Building Administrator, American Legion, Ray Goding Post, Presque Isle, Maine (1947-1948); Self-employed (1948-1951)--Inventor and manufacturer of Clark's "Spot-Eyed" Flies; University of Maine (1951-1953)--Assistant Athletic Trainer; Boston University (1953-1954)--Teaching Fellow in Biology; Detroit Country Day School, Detroit, Michigan (1955-1956)--Director of Physical Education, Teacher-Coach; Detroit Public Schools (1956-1958)--Physical Education.

Recognitions: A selection on the All-Maine High School Football, Basketball, Baseball, and Track Teams (1931-1932); Scholarship to Bates College; Selection as an All-Maine End representing Bates College (1935).

Memberships: Presque Isle High School Band and Orchestra; Presque Isle Community Band; Bates College Band; Bates Outing Club; Bates Varsity Club; Maine Education Association; National Education Association; National Association for Health, Physical Education, and Recreation; The Aroostook Federation of Fish and Game Clubs; The Maine Federation of Fish and Game Clubs; The New England Outdoor Writers' Association; Maine High School School Coaches' Association; The American Legion; Phi Delta Kappa; The Wayne State University Doctoral Club; Michigan Education Association.

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