THE EFFECTS OF MENTAL PRACTICE

UPON A SELECTED MOTOR SKILL

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by

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Approved for the Major Department

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CHAPTER I

DEFINITION OF THE PROBLEM

The theory that practice makes perfect, if practiced perfectly, has been in fairly common acceptance among physical educators for many years. Practice had been understood to be physical repetition of the movements necessary to accomplish a desired effect such as tossing a horseshoe ringer, striking a pitched ball with a bat, or shooting a basketball.

Another and more recent development in the area of practice is that of mental practice. Experiments in the area of mental practice were initiated in the early 1930's by researchers seeking understanding of different methods of learning directly related to methods of practicing to learn. One form of practice that was of particular interest was that of mental practice. Physical education researchers sought an answer to the question of whether the mind could effect the end accomplishment without physical practice. According to Twining, "There was little doubt that knowledge of the mental activity required for efficient motor learning would aid physical educators in an understanding of teaching techniques."[1] In some cases, it appeared that mental

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[1]Wilber E. Twining, "Mental Practice and Physical Practice in Learning a Motor Skill," Research Quarterly, 20:432, December, 1949.

practice did produce a similar effect to physical practice upon influencing the performance of selected motor skills. In other cases, no benefits from mental practice were noted. However, the studies did reveal a need for more research in the areas of mental practice and its effect on motor skills.

I. THE PROBLEM

Statement of the problem. The purpose of this study was to investigate the effects of a period of mental and physical practice upon the manipulative dexterity of junior high school boys. Specifically this study attempted to ascertain effectiveness upon manipulative dexterity of junior high school boys as developed by mental and physical practice. The questions asked were: (1) can performance on the assembly sequence of the Purdue Pegboard test be significantly changed by mental or physical practice, and (2) when these two forms of practice are compared, will there be a significant difference of performance caused by either of these two methods.

Statement of hypothesis. The hypothesis for this study was: there is no significant difference between a group using mental practice and a group using physical practice in performing a test of manipulative dexterity.

Importance of the study. The amount of time required for physical practice of a motor skill may oftentimes be a reason

for some people not enjoying such lifetime sports as golf, bowling, or tennis. Perhaps if mental practice of motor skills can aid in the competence of performance without using the time required for physical practice, the people who do not have the time for physical practice could improve their skills by mentally practicing the skill such as a golf swing, a curling glide, or dart toss.

II. DEFINITION OF TERMS

Mental practice. Mental practice refers to the symbolic rehearsal of the physical activity without any gross muscular movements. When the subject sits in front of the pegboard and in imagination goes through the motions of the assembly test, he is engaged in mental practice.

Physical practice. Physical practice refers to the gross muscular movements used when a person is engaged in physical activity. When the subject sits in front of the pegboard and is physically going through the motions of the assembly test, he is engaged in physical practice.

Test of manipulative dexterity. The Purdue Pegboard used in this study was developed by the Purdue Research Foundation, Purdue University, and is a test of dexterity for measuring two types of activity: one involving gross movements of hands, fingers and arms,

and the other involving primarily what might be called "fingertip" dexterity.[2]

The Purdue Pegboard. The Purdue Pegboard is a test of dexterity designed to aid in the selection of employees for industrial jobs such as assembly, packing, operation of certain machines, and other manual jobs. The Pegboard is equipped with pins, collars, and washers which are located in four cups at the top of the board. The extreme right-hand and extreme left-hand cups contain twenty-five pins. The cup immediately to the right of center contains twenty collars, and the cup immediately to the left of the center contains forty washers.

The Purdue Pegboard assembly sequence. This testing sequence consists of assembling pins, collars, and washers. Both hands should be operating all the time; one picking up a pin, one a washer, one a collar and so on.

III. LIMITATIONS OF THE STUDY

This study was limited to sixty eighth and ninth grade male students enrolled in physical education during the spring, 1970, at Atchison County Community Junior High School at Effingham, Kansas. It is possible that these groups may have been very

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[2]Joseph Tiffin, Purdue Pegboard Examiner Manual (Chicago: Science Research Associates, Incorporated, 1968), p. 2.

different from one another. It was assumed for the study that there were no great differences in the attitudes, abilities, and past experiences prior to the testing procedures. The physical education classes were conducting units on basketball, wrestling, and handball at the time of the study. Ten boys from each unit were combined into a grouping of thirty until the two groups were formed for testing. The boys themselves decided which sports unit they would enter, and the instructor of each unit sent ten boys for testing without knowing to which group they would be assigned.

CHAPTER II

REVIEW OF THE LITERATURE

The reviewed literature dealing with the effects of mental practice upon motor skills has been divided into categories and placed under these headings: (1) Studies pertaining to the effects of mental practice on physical skills and (2) Studies pertaining to the effects of exercise on mental learning and performance.

I. STUDIES PERTAINING TO THE EFFECTS OF MENTAL PRACTICE ON PHYSICAL SKILLS

On the basis of reviewing previous research concerning the relationship of mental practice to performance, Richardson made the following tentative conclusions concerning the effects of mental practice on skill performance: (1) eleven statistically significant findings associate mental practice with improved task performance, (2) seven more studies indicate a positive trend, and (3) three studies report mental practice was negative while one study indicates no effect.[3]

An attempt to compare symbolic rehearsal (mental practice) and physical practice using a maze problem was done by Sackett. Sixty university males were placed in groups of twenty each:

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[3]Alan Richardson, "Mental Practice: A Review and Discussion, Part II," Research Quarterly, 38:263-273, May, 1967.

(1) thinking, (2) drawing and (3) non-rehearsal. The subject groups were approximately equated in age and learning ability. After a one hour period or less of learning the maze, group (1) was instructed to think often about the maze, but not to draw or trace the design; group (2) was to draw the maze as often as possible during the next six days, and to draw five times after learning and five times before relearning; group (3) was not to draw, trace or think about the maze pattern. Final testing was on the seventh day. Conclusions were made that symbolic rehearsal (drawing) is beneficial in retaining a maze habit. Symbolic rehearsal (thinking) is beneficial, but not as effective as drawing in retention of a maze path after one week.[4]

A study using a direct approach to isolate the effects of mental practice in the learning of a motor skill was done by Vandell, Davis, and Clugston in 1942. Motor skills used were basketball free throws and dart tossing. Twelve senior high, twelve junior high, and twelve college freshman males were used in the testing under the following practice conditions:

1. Control group of twelve practiced only the first and twentieth day.
2. Physical practice group of twelve practiced each day.

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[4]Robert S. Sackett, "The Influence of Symbolic Rehearsal upon the Retention of a Maze Habit," Journal of General Psychology, 10:376-398, 1934.

3. Mental practice group of twelve mentally rehearsed at imaginary targets fifteen minutes per day from the initial test until the twentieth day when they again were tested.

No statistical analysis of results was made. However, considering percentage improvements, the authors concluded that mental practice was about as effective as physical practice under the conditions of the experiment.[5]

In 1949, Twining used thirty-six college men selected at random in a ring tossing experiment under these conditions:

1. Twelve threw 210 rings on the first and twenty-second days.
2. Twelve threw 210 rings on the first day, 70 per day until the twenty-second day when they threw 210.
3. Twelve threw 210 rings on the first day; mentally rehearsed tossing rings for fifteen minutes per day until they threw 210 rings on the twenty-second day.

The physical and mental practice group both improved significantly while the control group did not. Improvement percentages were control, 4.3 per cent; mental practice, 36.2 per cent; and physical practice, 137.3 per cent. Twining concluded that both physical

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[5]Roland A. Vandell, Robert A. Davis and Herbert A. Clugston, "The Function of Mental Practice in the Acquisition of Motor Skills," Journal of General Psychology, 29:243-250, 1943.

to be nearly as effective as physical practice under the conditions of the experiment.[7]

A study by Kelsey to determine whether muscular endurance could be increased through mental rehearsal of an exercise found that mental practice did result in a significant gain in muscular endurance. Using three groups (physical practice, mental practice and no practice) of boys from physical education activity classes randomly assigned to the testing study and then assigned to groups by matching pairs, Kelsey followed his initial test of "total number of sit-ups" with twenty days of a practice period five minutes in length for the physical and mental practice groups. The control group was not to practice, talk or think about sit-ups during this time. On the twenty-second day all groups were retested. The no practice group showed no significant improvement. Both the physical and mental practice groups improved significantly. However, Kelsey concluded that the degree of increase in muscular endurance gained through mental practice was not sufficiently large enough to be used when physical practice is possible, nor was mental practice as effective as physical practice in increasing muscular endurance.[8]

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[7]L. Verdelle Clark, "Effect of Mental Practice on the Development of a Certain Motor Skill," Research Quarterly, 31:560-569, December, 1960.

[8]Ian Bruce Kelsey, "Effects of Mental Practice and Physical Practice upon Muscular Endurance," Research Quarterly, 32:47-54, March, 1961.

K. B. Start in measuring the relation between intelligence and improvement of a gross motor skill after mental practice, used forty-four male college students who had been administered the A. B. Forty test of general intelligence by their college. The gross motor skill used in testing was the single leg upstart on the Olympic high bar. This skill was unfamiliar, could be controlled by the necessity of equipment and involved movement of the whole body. For six days the subjects were given five minutes of mental rehearsal. On the seventh day they performed the skill for the first time and were rated by a panel of three experienced judges. Results indicated that intelligence has low to trivial correlation with estimates of physical performance.[9]

One hundred and twenty male right-handed volunteers from physical education classes were used in an investigation by Egstrom to study the effects of varying degrees of emphasis on conceptualizing techniques during the early learning of a novel gross motor skill. The task was to strike a ball with a wooden paddle, held in the left hand, towards a target twenty feet distant. Following an initial test, the subjects were randomly assigned to six groups of twenty each in the following pattern: manual practice only, early manual practice, early conceptualizing

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[9]K. B. Start, "Intelligence and the Improvement in a Gross Motor Skill after Mental Practice," British Journal of Educational Psychology, 34:85-89, February, 1964.

practice, alternate periods of manual and conceptualizing practice, conceptualizing practice only, and no practice. After three weeks of experimentation, the final testing caused Egstrom to form these generalizations:

1. The conceptualizing practice theory is effective as a method for acquiring and improving gross motor skills.
2. Manual practice appears more effective than conceptualizing practice for acquiring and improving gross motor skills.
3. There appear to be some advantages in using a method of alternating manual and conceptualizing practice during the learning of a gross motor skill.
4. There appeared to be cause for considerable skepticism about the value of conceptualization practice not used with manual practice.[10]

Four groups were used in a study by Halverson to compare three methods of teaching motor skills. Fifteen freshman college women were selected for each group. The task to be performed was a basketball throw. Following the initial test the groups used the following procedures: (1) no practice group - did not practice, (2) demonstration group - watched a demonstration

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[10]Glen H. Egstrom, "Effects of an Emphasis on Conceptualizing Techniques during Early Learning of a Gross Motor Skill," Research Quarterly, 35:472-481, December, 1964.

and then used physical practice followed by criticism, (3) kinesio-logical group - practiced basketball throwing, but without a basket to aim at, and (4) mental practice group - stood facing the basket mentally practicing. Halverson found that the three comparison groups improved significantly although the mental practice group improved the least. The no practice group did not improve.[11]

In a study by Corbin to compare the effects of mental and physical practice on skill development, thirty high school boys practiced a wand juggling task for five consecutive days. Following the practice, the boys were randomly assigned to either the control, the mental practice, or the physical practice group. The task to be performed was a wand-juggling skill which involved flipping an eighteen inch wand with two thirty-six inch wands held in the hands. For testing and practice, thirty attempts at flipping the wand were used flipping alternately to the right and left. The control group did no practicing of any kind for thirteen days. The mental practice group practiced according to a direction sheet which was read each day for thirteen days. The physical practice group practiced with the wands for thirteen days. All groups received instructions to not practice outside

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[11]L. E. Halverson, "A Comparison of Three Methods of Teaching Motor Skills" (microcarded Master's thesis, University of Wisconsin, 1949).

the group sessions. After the thirteen practice sessions, all groups were tested for two consecutive days. The results revealed that the control group did not improve, the mental practice group showed improvement and the physical practice group improved significantly. Corbin concluded that physical practice, singly, was the superior type of practice in performing motor skill tasks, and that mental practice did seem to facilitate actual skill performance following controlled practice.[12]

The effectiveness of mental practice when combined with audio, visual and audio-visual instruction in developing the forehand tennis drive was studied by Surburg using 183 male junior college students. In the initial testing all subjects were administered an adaptation of the Bruer-Miller tennis test on two consecutive days. They were then randomly divided into the following groups:

Experimental groups:
(1) audio-mental practice
(2) visual-mental practice
(3) audio-visual-mental practice

Parallel groups:
(1) audio
(2) visual
(3) audio-visual

The Bruer-Miller tennis test (adapted) used to determine skill in the forehand drive consisted of extending a rope one foot above

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[12]Charles B. Corbin, "Effects of Mental Practice on Skill Development after Controlled Practice," Research Quarterly, 38:534-538, December, 1967.

and parallel to the net. One-half of the court plus ten feet beyond the baseline was divided into six marked segments with values of two, four, six, eight, six, four, and balls beyond the last segments, two. The subject would stand behind the baseline of the unmarked half of the court, bounce the tennis ball, and stroke twenty-two balls. The balls going between the rope and the net received full value. A ball passing above the rope received one-half scoring value. Following the initial test, the training program consisted of three practice sessions per week for eight weeks. The experimental audio-visual-mental practice group watched and listened to a sound film-strip, Forehand Drive. The audio-mental practice group listened to the recorded portion without viewing the filmstrip. The visual-mental practice group viewed the filmstrip without listening to the record. During the last ten minutes of each session, the subjects sat conceptualizing the execution of the forehand drive. Corresponding parallel groups received some of the same instructions. Their sessions ended with the presentations of sound and/or vision of Forehand Drive with no follow-up practice. The control group engaged in no type of practice and was instructed not to discuss tennis. After the eight week training period and the final testing, Surburg found that the mental practice groups did improve significantly while the parallel groups without mental practice did not significantly improve. Surburg concluded

that the presentation of audio, visual, and audio-visual instructions used in conjunction with mental practice improves the forehand tennis drive.[13]

Bowers studied the effects of autosuggested muscular contractions on muscle strength and size compared with the effects of isometric and static contractions. Sixty-one university males participated in the six week study. The measures of elbow flexion strength were taken using a cable tensiometer and a specially designed chair. Tests were administered before beginning the exercise program, after three weeks, and after six weeks of exercise. Bowers concluded that either isometric, static or autosuggested muscular contractions will significantly improve strength, but not muscle size over the six week period using the prescribed practice procedures.[14]

In a study by Stebbins to determine the effects of mental practice compared to physical practice in learning a motor skill, ninety-three college male volunteers enrolled in physical education classes were employed as subjects. Five classes met

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[13]Paul R. Surburg, "Audio, Visual, and Audio-visual Instruction with Mental Practice in Developing the Forehand Tennis Drive," Research Quarterly, 39:728-734, October, 1968.

[14]Louis A. Bowers, "An Investigation of the Effects of Autosuggested Muscle Contraction on Muscular Strength and Size," (paper presented at the American Association for Health, Physical Education and Recreation National Convention, Dallas, Texas, 1965).

three times weekly with the subjects randomly assigned to five treatment conditions: control, mental practice, physical practice, mental-physical practice, and physical-mental practice. Each subject was initially tested using an experimental apparatus consisting of a target and five rubber balls which were thrown at the target. The ball would lodge in the bull's eye pattern to receive a score value. All the subjects were given the same test again after eighteen practice sessions which were prescribed by Stebbins. The findings indicated that the main difference between initial and final testing showed that the mental-physical and physical-mental practice groups did improve significantly. The mental and physical practice groups did not improve. Stebbins concluded that mental practice did not produce any improvement in learning simple hand-eye coordination skill; also that in learning a simple hand-eye coordination skill, the greatest improvement is made in using a combination of practice conditions.[15]

One of the most recent studies was by Shick in 1969. Three substudies were conducted to determine the effects of mental practice on improving the skills of serving and volleying using a volleyball: (1) mental practice, ten subjects practicing three minutes daily each skill for two weeks compared with no

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[15]Richard J. Stebbins, "A Comparison of the Effects of Physical and Mental Practice in Learning a Motor Skill," Research Quarterly, 39:714-720, October, 1968.

practice; (2) mental practice, sixty-eight subjects practicing three minutes daily each skill for five weeks compared with equal time for physical practice; and (3) mental practice, thirty-six subjects practicing for one minute daily for three weeks compared with equal time for physical practice. Two additional areas were studied. Group three utilized a questionnaire concerning the periods of mental practice, and electromyographic measurements of intrinsic muscular involvement during mental practice periods were obtained from nineteen subjects. The subjects of the study were college females with experience in volleyball. The tests of serving and wall volleying were modifications of the French and Cooper study on achievement tests for volleyball. Volleying skill tests showed no significant improvement. Serving skill tests revealed mental practice significantly superior to no practice, and three minutes of mental practice was superior to one minute of mental practice. The questionnaire and electromygraphy records showed a correlation resulted, but no single variable could be said to determine improvement scores.[16]

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[16]Jacqueline Shick, "Effects of Mental Practice on Selected Volleyball Skills for College Women," Research Quarterly, 41:88-94, March, 1970.

II. STUDIES PERTAINING TO THE EFFECTS OF EXERCISE ON MENTAL LEARNING AND PERFORMANCE

One hundred and twenty freshman males selected and grouped on the basis of scores on the Taylor manifest anxiety scale were used to study motor performance under stress by Carron. Using a control group, stress-early group, and stress-late group, Carron compared the effects of stress using an electric shock device applied through the index finger during the practicing of balancing on a stabilometer platform. All subjects were given seventy twenty second trials over a two day period. Carron concluded that a high-anxious, stress-early group was significantly inferior to other learning groups during the experiment. Late-stress resulted in a significant lowering of performance levels for high and low anxious groups. Removal of stress caused both anxious levels to significantly improve their task performance.[17]

A study to determine whether increased muscular tension exerts an influence upon the efficiency of performance of a mental task was done by Bills. Four female and five male advanced college students acted as subjects. Through comparing scores, Bills found that increased muscular tension did increase

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[17]Albert V. Carron, "Motor Performance Under Stress," Research Quarterly, 39:463-469, October, 1968.

the efficiency of the performance of the mental task.[18]

Another study investigating the effects of muscular tension upon the performance of a mental task was conducted by Zartman and Cason. Twelve female and Six male college students performed the mental task while pressing a foot pedal with varying degrees of pressure. This study concluded that increased tension does not increase the efficiency of performing the mental task.[19]

Benson used forty-one male subjects to compare the effects of practice performed by an experimental group during a fatigued state on the learning of two motor skills of hop-stepping and juggling against a control group over a six week period. Fatigue was developed by performance of a bicycle exercise. Findings indicated that fatigue has a differential effect on learning dependent upon the nature of the task being learned. Although speed in the jumping task was impaired by fatigue, accuracy was improved by practice while fatigued. Learning to juggle was also improved by practicing while

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[18]Arthur G. Bills, "The Influence of Muscular Tension on the Efficiency of Mental Work," American Journal of Psychology, 38:227-251, 1927.

[19]Edna N. Zartman and Hulsey Cason, "The Influence of an Increase of Muscular Tension on Mental Efficiency," Journal of Experimental Psychology, 17:671-679, 1934.

fatigued. Benson concluded that based on his study, fatigue has no effect on learning.[20]

A twelve week study by Gutin comparing the differences in performance of a mental task (Employee Aptitude Survey) by a control group and a group performing three exercises found no significant difference in the improved levels of performance. However, the subjects who improved significantly in physical fitness also improved significantly on the mental task.[21]

Gutin and DiGennaro experimented with the effect of a treadmill run on the performance of long addition. Seventy-two male college students ran upon a treadmill until unable to continue. Each subject then added single columns of ten numbers for four minutes. The subjects acted as their own control group by taking the addition test another day without running the treadmill. No significant effect on addition speed was found, but the exertion had a significant negative effect on addition accuracy.[22]

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[20]David W. Benson, "Influence of Imposed Fatigue on Learning a Jumping Task and a Juggling Task," Research Quarterly, 39:251-257, May, 1968.

[21]Bernard Gutin, "Effect of Increase in Physical Fitness on Mental Ability Following Physical and Mental Stress," Research Quarterly, 37:211-220, May, 1966.

[22]Bernard Gutin and Joseph DiGennaro, "Effect of a Treadmill Run to Exhaustion on Long Addition Performance," Research Quarterly, 39:958-964, December, 1968.

One hundred and eight male college students were placed into four treatment groups in a study by McAdam and Wang to determine whether exposure to a single encounter with exercise would influence performance of a simple mental task. The first group exercised in a prescribed manner, the second had typical classroom instruction, the third laid on mats listening to soft music, and the fourth group took an immediate retest of the mental task. After the initial mental task, each group used ten minutes of prescribed treatment, then again performed the mental task. Analysis of variance revealed no significant difference among performances of the groups. However, the rest group and the exercise group did show more improvement than the other groups.[23]

Another study to determine to what extent a single exposure to exercise would modify the performance of male college students in a paper and pencil symbol-substitution mental task was conducted by Giese, McAdam, Milton, and Wang. One hundred and fifty-seven subjects were divided at random into four treatment groups: (1) run-jog-walk, (2) laying upon mats listening to sleep-promoting music, (3) viewing a film on the volleyball serve, and (4) retaking an alternate test. After exposure to the prescribed

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[23]Robert E. McAdam and Yuan Kai Wang, "Performance of a Simple Mental Task Following Various Treatments," Research Quarterly, 38:208-212, May, 1967.

treatments, all groups took an alternate test. Analysis of variance revealed no significant difference among performance of the groups although the rest group and the exercise group improved more than the other groups.[24]

Divine conducted a study to determine the effects of exercise and relaxation on the ability to perform a simple mental task using fifty-two high school girls and forty-nine high school boys. The subjects were divided into a retest group, an exercise group, and a relaxation group. Following an initial test of figure-letter association lasting five minutes, the groups performed the prescribed group treatments and then again took the test. Divine concluded that all groups demonstrated significant improvement with the exercise group improving more than the other groups.[25]

III. THEORETICAL IMPLICATIONS OF PREVIOUS RESEARCH

Most of the data compiled in previous studies seems to imply that mental practice combined with physical practice is

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[24]David Giese, Robert McAdam, George Milton, and Peter Wang, "The Role of Exercise in the Performance of a Simple Mental Task" (University of Minnesota, Minneapolis, 1966), pp. 1-14. (printed copy.)

[25]Darrell W. Divine, "The Effects of Exercise and Relaxation on the Ability to Perform a Simple Mental Task" (unpublished Master's thesis, Kansas State Teachers' College, Emporia, Kansas, 1967), pp. 1-29.

the better method for improving motor skills. Indications are that the use of mental practice of motor skills fosters the development of an improved level of performance. Implications are quite strong that additional research is needed in the area of mental practice and the improvement of motor skills.

IV. RELATION OF THIS RESEARCH TO PREVIOUS RESEARCH

The relationship of this research to the previous research was a supportive one in that the findings of this research were expected to contribute additional knowledge and evidence that mental practice could produce improvement in the level of performance of a selected motor skill. This study was limited in that the subjects represented only one group from one school.

CHAPTER III

PROCEDURES

I. GENERAL OVERVIEW

The proposed study was essentially a comparative one in which the manipulative dexterity of each group was measured before and after meeting the conditions of practice used in the study. Sixty eighth and ninth grade boys enrolled in physical education classes were employed as subjects. The boys were involved in one of three sections at the time of testing: wrestling, basketball, or handball. The boys decided for themselves which section they participated with. Assignment to the testing was made by the instructor in charge of each section who sent the subjects to be placed by the investigator into either the physical or mental practice group. Each subject was treated individually during his five day testing period. As only one pegboard was used, the complete testing of all subjects lasted six weeks.

Physical practice group. On the first day, thirty boys were administered the initial test. They practiced the assembly sequence for three days. On the fifth day, they were administered the final test.

Mental practice group. The initial test was completed by thirty boys. For three days they sat before the Purdue

Pegboard mentally practicing the physical movements for the assembly sequence. They were administered the final test on the fifth day.

II. TESTING PROCEDURES

Initial testing. The subjects were seated at a table approximately thirty inches high. The pegboard was on the table directly in front of the subject with the row of cups at the far end of the board. If a subject preferred his left-hand for a majority of tasks, the examiner modified the directions by substituting "left hand" for "right hand." The directions for the administration of the Purdue Pegboard assembly sequence are in Appendix A.

Each person was shown how to make two complete assemblies. Then the subject made five trial assemblies to make certain he understood the task. After returning the pieces to the cups, the subjects were ready for the initial testing. The initial test consisted of three trials of one minute each. The totals were recorded as established by the Industrial Test Development Section of Science Research Associates, Incorporated, using the sum of the three trial scores.

Final testing. The final testing procedures duplicated the initial testing procedures. The final test was administered to all subjects on the fifth day following their initial test.

III. TRAINING PROCEDURES

Practice sessions for the physical practice and the mental practice group individuals were held during the three days following each subject's initial test. The physical practice subjects followed the same procedures of the initial test each day for three days.

The mental practice subjects followed the procedures for the initial test except that they remained seated with their hands beside the Pegboard and mentally rehearsed the physical movements to be followed in the performance of the assembly sequence.

IV. STATISTICAL ANALYSIS

For both the physical practice and mental practice groups, the initial and final assembly sequence scores on the Purdue Pegboard were analyzed to determine significance of gains in performance, through using the t test of the difference between the means of the two groups.

The t test was also used to determine if significant differences existed between the mental and physical practice group scores on the initial test and on the final test.

CHAPTER IV

ANALYSIS OF DATA

I. INTRODUCTION

The statistical analysis computed in studying the effects of mental practice and physical practice upon the performance of a test of manipulative dexterity was the *t* test for the significance of difference between the correlated means.

The data used in the study were gains made between the initial and final scores on the assembly sequence of the Purdue Pegboard test of manipulative dexterity.

II. THE SIGNIFICANCE OF THE MEAN GAIN FOR EACH GROUP IN PERFORMING THE ASSEMBLY SEQUENCE

To compare the initial and final assembly sequence scores, *t* tests were computed to establish the significance of the mean gains for the physical practice group and the mental practice group. In order to reach significance, a *t* of 2.70 was needed at the .01 level of probability, and a *t* of 2.02 was necessary at the .05 level of probability. Table I indicates that a significant *t*-ratio was obtained for both groups. The physical practice group had a mean difference of 15.133 between the initial and final test scores resulting in a *t* of 4.39 which was significant at the .01 level of probability. This significant gain suggests

TABLE I

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE INITIAL AND FINAL ASSEMBLY SEQUENCE SCORES ON THE PURDUE PEGBOARD

Group	N	Initial Mean	Final Mean	Mean Difference	t	P
Physical Practice	30	111.367	126.500	15.133	4.391	.01
Mental Practice	30	110.833	116.367	5.534	2.509	.05

t needed for significance at .01 = 2.70
.05 = 2.02

that physical practice of the assembly sequence on the Purdue Pegboard will result in an improvement of the scores attained on the assembly sequence. The mental practice group had a mean difference of 5.534 between the initial and final test scores on the assembly sequence with a t-ratio of 2.51 which was significant at the .05 level of probability. This significant difference also indicates that mental practice for the assembly sequence on the Purdue Pegboard will result in an improvement of the scores attained on the assembly sequence. Since the t-ratio, 4.39, of the physical practice group was higher than the t-ratio, 2.51, of the mental practice group; the assumption that physical practice of the assembly sequence is superior to mental practice of the assembly sequence in achieving improved performance on the Purdue Pegboard can be made providing that the initial tests were homogeneous comparing the two groups.

III. THE SIGNIFICANCE OF THE INITIAL TEST SCORES FOR EACH GROUP

A comparison was made with the t test used to determine if there existed any significant difference between the mental practice group and the physical practice group using the data compiled from the initial test scores of the assembly sequence. This comparison and the data are shown in Table II. In order to reach significance, a t of 2.05 was necessary at the .05 level

TABLE II

TEST FOR SIGNIFICANCE OF DIFFERENCE BETWEEN GROUPS ON THE ASSEMBLY SEQUENCE PRETEST SCORES

Group	N	Standard Deviation	Mean Score	t	P
Physical Practice	30	12.989	111.367	0.191	-
Mental Practice	30	7.652	110.833		

t needed for significance at .01 level = 2.75
.05 level = 2.05

of probability. The mean difference between the physical practice group and the mental practice group was 0.534 with a resulting *t* of 0.191 which was not significant. This indicates that there was no significant difference in the scores achieved by each group on the initial test of the assembly sequence. In measuring manipulative dexterity using the Purdue Pegboard, the two groups could be considered equal in ability prior to beginning the physical and mental practice sessions.

IV. THE SIGNIFICANCE OF THE FINAL TEST SCORES FOR EACH GROUP

To establish the significance of the mean scores on the final test which followed the practice sessions, *t* tests were computed comparing the final mean scores of the two groups. In order to reach significance, a *t*-ratio of 2.75 was needed for the .01 level of probability. The physical practice group scored 10.133 higher as a mean than did the mental practice group on the assembly sequence of the Purdue Pegboard test. The comparison of final test scores shown in Table III indicates that the *t* of 3.393 is significant which suggests that physical practice of the assembly sequence will result in higher scores being achieved on the Purdue Pegboard test compared to the scores achieved by a group using mental practice of the assembly sequence.

TABLE III

TEST FOR SIGNIFICANCE OF DIFFERENCE BETWEEN GROUPS ON THE ASSEMBLY SEQUENCE FINAL TEST SCORES

Group	N	Standard Deviation	Mean Score	t	P
Physical Practice	30	13.276	126.500	3.393	.01
Mental Practice	30	9.098	116.367		

t needed for significance at the .01 level = 2.75
.05 level = 2.05

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

The purpose of this study was to determine the effectiveness of mental and physical practice upon the performance of a test of manipulative dexterity.

Subjects for the study were sixty eighth and ninth grade males enrolled in physical education classes during 1970 at Atchison County Community Junior High School at Effingham, Kansas. All subjects were individually administered the assembly sequence on the Purdue Pegboard test which served as the initial measure of manipulative dexterity. The subjects were divided into two groups by the investigator who attempted to homogeneously group them as they were sent for testing by their unit instructors. The mental practice group mentally rehearsed the gross muscular movements of the assembly sequence procedure for the next three days, and the physical practice group physically practiced the assembly sequence procedures on the Purdue Pegboard for the next three days. Each subject was administered the final test on the fifth day following his initial test. As only one Pegboard was used, the entire testing period lasted six weeks.

The *t* test was used to determine if there existed any significant differences in the scores achieved on the tests

taken by the groups. Three comparisons were computed utilizing the *t* test:

1. Comparison of mean gains between initial and final testing for both groups.
2. Comparison of mean differences on the pretest between groups.
3. Comparison of mean differences on the final test between groups.

II. FINDINGS OF THE STUDY

The findings of this study were:

1. There was no significant difference between the groups at the beginning of the experiment as measured by their mean scores of manipulative dexterity on the initial test.
2. The mental practice group produced a significant gain in ability to perform a test of manipulative dexterity following the prescribed sessions of mental practice.
3. The physical practice group produced a significant gain in ability to perform a test of manipulative dexterity following the prescribed sessions of physical practice.
4. Physical practice produced significantly higher gains in ability to perform a test of manipulative dexterity than mental practice could produce.

III. CONCLUSIONS

The following conclusions were made considering the limitations of this study:

1. Scores on a test of manipulative dexterity may be significantly improved by physical practice of the test.
2. Scores on a test of manipulative dexterity may be significantly improved by mental practice of the test.
3. Physical practice of a test of manipulative dexterity will bring about more improvement of test scores than will mental practice of a test of manipulative dexterity.

IV. RECOMMENDATIONS

As a result of the findings in this study, the following recommendations for further study are suggested:

1. A study employing the same experimental design, but including a no practice group.
2. A study employing the same experimental design, but including a group using both mental and physical practice in combination.
3. A study that includes different durations of time than the five days employed in this study.

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APPENDIX

APPENDIX A

ADMINISTRATION OF THE PURDUE PEGBOARD ASSEMBLY SEQUENCE

"This sequence consists of assembling pins, collars, and washers. Demonstrate the following operations while saying:

'Pick up one pin from the right-hand cup with your right hand, and while you are placing it in the top hole in the right-hand row, pick up a washer with your left hand. As soon as the pin has been placed, drop the washer over the pin. While the washer is being placed over the pin with your left hand, pick up a collar with your right hand. While the collar is being dropped over the pin, pick up another washer with your left hand and drop it over the collar. This completes the first assembly, consisting of a pin, a washer, a collar, and a washer. While the final washer for the first assembly is being placed with your left hand, start the second assembly immediately by picking up another pin with your right hand. Place it in the next hole, drop a washer over it with your left hand, and so on, completing another assembly. Now make a few assemblies for practice.'

After five practice assemblies have been made, say:

'Stop. Now return the pins, collars, and washers to the proper cups.'

Then say:

'When I say "Begin," make as many assemblies as you can, beginning with the top right-hand hole. Work as rapidly as you can until I say "Stop." Are you ready? "Begin."'

Start timing when you say "Begin." After <u>exactly one minute</u>, say:

'Stop.'

Repeat each test three times for the three-trial administration."[26]

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[26]Tiffin, <u>op. cit.</u>, p. 4.

APPENDIX B

TEST SCORES ON THE ASSEMBLY SEQUENCE

	Physical Practice	Mental Practice
Test I	85,86,87,87,88 88,110,110,110, 111,111,112,114, 114,114,114,116, 117,118,120,120, 121,121,121,122, 122,122,123,126, 126	96,96,97,98,98, 98,108,109,109, 110,110,111,111, 112,112,112,113, 113,115,116,116, 116,117,117,118, 118,119,119,119, 122
Test II	96,99,101,103, 106,108,122,123, 126,126,127,128, 128,129,130,130, 131,132,132,135, 135,135,136,136, 138,138,138,140, 140,142	99,100,104,104, 105,106,106,108, 109,112,113,114, 116,117,118,118, 119,121,121,121, 123,123,124,124, 125,125,125,128, 130,133