San Fernando Valley State College

THE INTERACTION EFFECTS OF GENERAL MOTOR ABILITY
AND LEARNING UNDER THREE CONDITIONS OF PRACTICE

A thesis submitted in partial satisfaction of the
requirements for the degree of Master of Arts in

Physical Education

by

Mildred Marie Ervin

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DEDICATION

This thesis is dedicated to DR. DAVID W. BENSON, Assistant Professor of Physical Education, in acknowledgment of his many hours of assistance and to the principal, faculty and students of St. Frances de Sales School for their cooperation in making this project possible.
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ABSTRACT

THE INTERACTION EFFECTS OF GENERAL MOTOR ABILITY
AND LEARNING UNDER THREE CONDITIONS OF PRACTICE

by

Mildred Marie Ervin

Master of Arts in Physical Education

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 Ninety junior high school girls participated in a study to investigate the interaction of general motor ability and learning under three conditions of practice. Subjects were classified as high, medium, or low in motor ability in groups of thirty on the basis of composite T scores on the Scott General Motor Ability Test. Ten subjects in each level of motor ability were randomly assigned to either physical, mental, or a combination of mental and physical practice. This method of grouping resulted in a standard three by three experimental design.

The novel skill involved hitting a table tennis ball off a stand, with a paddle held in the non-preferred hand, at a target ten feet away. Subjects were tested for initial ability, practiced according to their respective methods for twelve days, and re-tested on the last day.

Analysis of data revealed statistically significant performance differences between the High and Low Motor
Ability Groups on the basis of pre-and post-test scores on the novel skill. Practice conditions and interaction effects failed to result in significant performance differences between groups. t-tests showed significant mean differences between pre-and post-test performance scores on the novel skill for all experimental groups beyond the five percent level of confidence.

Learning was defined as percent gain possible score. This score was calculated by subtracting the sum of the post-test scores from the sum of the pre-test scores and dividing by the sum of the highest possible score minus the sum of the pre-test score. Analysis of variance revealed a lack of significant learning differences between any of the experimental groups. Since the F value of 3.00 for the practice groups came close to reaching the 3.11 needed for significance, t-test comparisons were made between the learning scores of the practice groups. The t-test comparisons indicated learning differences between the Combination and Mental Practice Groups in favor of the Combination Practice Group.

Based on the findings the following conclusions appeared justified: (1) the Scott General Motor Ability Test has validity for classifying subjects into performance groups, but not for predicting learning differences, and (2) the interaction between level of motor ability and practice treatment failed to result in statistically sig-
significant performance or learning differences between groups.
CHAPTER I
INTRODUCTION

Physical educators are concerned with the skillful execution of movement. As professionals, they are obligated to learn about the nature, characteristics, and conditions of skill learning and successful performance by employing the methods of scientific research. Many of the variables that influence the learning of gross motor skills have already come under investigation and the implications for increasing teaching efficacy are being clarified.

Extensive hours of practice required by the trial-and-error method of motor learning impose an unnecessary hardship on both the learner and teacher. It is difficult to provide each student with the attention required by this method and highly skilled students may receive diminishing returns from increased hours of practice. More effective methods for motor learning are needed to insure the most advantageous use of learning time.

Because of this apparent need, the cortical facets of motor learning have received increasing emphasis in recent years. Twining was largely responsible for initiating research in the area when he observed:

In spite of the rapid advancement in the scientific approach to physical education, there is little in the literature to indicate just how much of motor learning is physical and how much is mental... The
very sparseness of reference to this concept in the literature serves all the more to emphasize the importance of this gap in our knowledge (50:432).

That mental practice is effective in learning gross motor skills has subsequently been supported by a number of investigations (11,22,32,43). Of particular concern is the identification of variables that influence the effectiveness with which an individual can learn by mental practice.

General motor ability has been identified as a possible variable influencing the amount of motor improvement resulting from mental practice. The concept of general motor ability is based on the assumption that motor ability is an individual trait and is indicative of an individual's ability to perform a wide variety of skills. Research in the area of general motor ability has produced contradictory results (19,23,31,56). Some investigations (3,9,33,37,52) have supported the concept of general motor ability, while other research (14,16,30,31) has found motor ability highly specific in nature.

General motor ability tests are used by the physical educator for classifying students into homogeneous performance groups. The relationship of general motor ability to learning new skills under the conditions of physical and mental practice needs clarification. Increased understanding of the variables affecting mental practice will enable physical educators to utilize this concept with
greater effectiveness.

The Problem

Purpose of the study

The study was concerned with the problem of identifying the role of general motor ability in the learning of motor skills under differing conditions or practice.

Statement of the problem

The purpose of this study was to determine the interaction of general motor ability on the learning of a gross motor task under the conditions of physical practice, mental practice, and a combination of mental and physical practice.

Specifically, the study was designed to answer the following questions:

1. Do subjects classified as having high, medium, or low motor ability differ significantly in their ability to learn a motor skill?

2. Is there a significant difference between physical, mental, or a combination of mental and physical practice in the learning of a motor skill?

3. What are the interrelationships between level of general motor ability and the method of practice in the learning of a novel motor skill?

4. Under which practice condition does the greatest amount of learning take place?
Importance of Study

The learning of motor skills cannot be explained adequately in terms of a mind-body dualism. Physical educators support the theoretical proposition of the unity of man. Studies in the area of mental practice provide added support to the close association of cortical and physical activity. The findings of studies in the area of mental practice supply evidence in defense of the wholistic approach to motor learning.

This study will consider the effectiveness of mental practice when used by junior high school girls. Only a limited number of studies have reported using girls as subjects, and the findings of previous studies with male subjects cannot necessarily be applied to girls.

Additional information will be obtained concerning the effectiveness of mental practice in the learning of gross motor skills. Start pointed out the need for studies of this nature:

Most mental practice studies have dealt with simple motor skills, such as throwing. The efficiency of mental practice needs to be tested with skills involving movement of the whole body (44:85).

The present study will supplement knowledge about the learning of novel skills by using mental practice. As Start pointed out:

...controlling the amount of past experience removes the problem of varied prior experience and might tend to limit the effects to that of innate physical ability (if such a thing exists) and ability to learn
by "mental practice". (44;85)

Richardson cites two studies that have objectively measured general motor ability in an effort to determine the relationship between general motor ability and the ability to profit from mental practice of a motor skill. The results of these studies are contradictory (34:105). Further research appears to be justified to identify the variables which influence an individual's ability to profit from mental practice. Clarifying the conditions under which mental practice should be employed as a teaching technique should make practice time more efficient without sacrificing the speed or quality of learning. By employing new teaching methods under the most suitable conditions, teachers would be able to develop a more effective learning situation to meet individual student needs.

Scope and Limitations

The study was limited to ninety girls in the seventh and eighth grades attending St. Frances de Sales School in the fall of 1966. All subjects volunteered to participate in the study.

All references to learning are inferred from performance scores on the novel motor task. The study extended over a fourteen day period. Subjects practiced daily, Monday through Friday, for three consecutive weeks. All comparisons in learning were based on initial and final performance scores and on percent gain possible score.
Percent gain possible score has proved to be one of the most valid methods of determining learning differences (28:453).

General motor ability classification was limited by the validity and reliability of the Scott General Motor Ability Test (37:75). Generalizations of the findings were valid only to the extent that the test was representative of general motor ability.

It was impossible to control mental practice of the motor skill outside the experimental situation; however, subjects were instructed not to participate in such outside practice. The equipment needed to perform the motor skill was not available to the subjects except during the experimental practice period.

Random assignment to experimental practice groups within general motor ability groups was the only provision made to control the effects of such variables as initial task skill level, intelligence, motivation and psychological differences.

Hypothesis and Assumptions

Stated in null form, the hypothesis tested in this study was that there would be no significant differences in ability to learn a novel motor task under the conditions of physical practice, mental practice, and a combination of mental and physical practice when the subjects were grouped according to motor ability.
The study made the following assumptions:

1. Mental practice is a condition that can be controlled and can be performed by subjects in learning a motor skill.

2. The effectiveness of mental practice can be inferred from performance scores.

3. The novel skill, developed in consultation with Egstrom (58), was learnable, capable of being mentally practiced, and sufficiently difficult to discriminate between the effectiveness of different practice techniques.

4. General motor ability can be measured.

5. The function of general motor ability in the learning of a motor skill can be inferred from the differences in the means and standard deviations between groups.

**Definition of Terms**

For the purposes of this study the following definitions apply:

1. Learning—the change in performance scores between the initial and final test, calculated in terms of the percent gain possible score.

2. Percent gain possible score—sum of the post-test score minus the sum of the pre-test scores divided by the highest possible score minus the sum of the pre-test scores.

3. Gross motor skill—a skill that requires movement of major muscle groups.
4. General motor ability--the score obtained on the Scott General Motor Ability Test.

5. Mental practice--thinking about and evaluating the movements involved in the execution of the skill with the aid of written cues and a sequence photograph of the skill.

6. Interaction effect--the extent to which two independent variables combine to cause an effect which neither variable could cause alone.

7. Novel motor skill--a skill that has not previously been practiced.

**Organization of Following Chapters**

The remainder of the study is organized into four chapters: II contains a review of the related literature in the areas of mental practice and general motor ability; III includes a description of the methodology used in the study; IV presents an analysis of the data; and a discussion and interpretation of the findings are included in V.
CHAPTER II
REVIEW OF RELATED LITERATURE

The review of related literature presented in this chapter was divided into two major areas as follows: (1) literature related to mental practice, and (2) literature related to motor ability.

The literature related to mental practice contains the following sections: (1) studies of mental practice and (2) summary and generalizations. Literature related to motor ability was divided into the following sections: (1) tests and studies supporting general motor ability; (2) studies supporting the specificity of motor ability; and (3) summary and generalizations.

Literature Related to Mental Practice

Studies of mental practice

In 1899, Anderson questioned whether muscles could be trained to execute gymnastics movements if the movements were thought of instead of physically practiced. His investigations found this to be possible; however, no statistical analyses were provided to substantiate his conclusions. His concept of the positive effects of introspective rehearsal was partly responsible for initiating more refined investigations (7:278).
Freeman measured the physiological effects of mental activity in 1931. He noted that a state of anticipation to receive stimuli resulted in a generalized increase in muscular tension before activity and a decrease in activity following activity, leading to the conclusion that sensory set is more generalized than motor set (15:479). Jacobson used an electromyographic technique and established that during imagination or recollection of muscular acts contraction occurs in the specific muscles that would have actually performed the acts (21:694). Shaw recorded the action potentials in nearly all the muscle groups to determine whether muscles were generally active in various parts of the body during imagining or whether there was a tendency toward localization of activity in the muscle groups commonly thought to be involved in the activity. Shaw concluded that action potentials were not localized in any part of the body (30:215). In two later studies, Shaw (40,41) found relationships between an increase in muscular action potentials and an increase in imaginal weight to be lifted (41:48).

In 1939 Perry attempted to determine the relative efficiency of actual and imaginary practice in five selected tasks. He found that both actual and imaginary practice were effective in improving scores. Perry concluded that the relative efficiency of imaginary and actual practice varies with the test used and that there
were some tests such as the peg-board test in which imaginary practice may be more effective than actual practice (32:75).

In a study similar to Perry's, Beugal concluded that the introduction of ideational contexts in the learning of a patterned motor skill resulted in a distinct advantage, at least during the initial stages of the learning process (10:124).

Early studies pertaining to mental practice and the retention of motor skills were conducted by Rubin-Rabson and Sackett. Rubin-Rabson found that mental rehearsal saved keyboard trials and was an effective for retention as a greater number of keyboard trials (35:602). Sackett investigated the influence of mental practice on the retention of a maze habit and concluded that symbolic rehearsal in any of the amounts investigated was beneficial to retention (36:396).

Vandell, Davis and Clugston studied the effects of physical practice, mental practice, and no practice on the learning of dart throwing and basketball free throwing. On the basis of percent improvement by junior high, senior high, and college boys, the following conclusions were drawn: (1) no practice results in no improvement in the particular skill; (2) daily physical practice results in gradually improved performance of the skill; (3) mental practice appears to be almost as effective as actual physical practice (51:250).
Twining designed a similar study using thirty-six college men performing a ring tossing skill. On the basis of mean percentage gains, there was a skill improvement by both the physical and mental practice groups. The physical practice group improved considerably more than the mental practice group; however, there was no statement as to the significance of this difference (50:435).

Contradictory results were reported in similar studies conducted by Steel and Clark. Using a baseball throw for accuracy, Steel concluded that "mental practice did not improve a ball throwing skill to a statistically significant degree" (49:108). Clark reported highly significant gains for the physical practice group and the mental practice group practicing the Pacific Coast One-Handed Foul Shot. An analysis of the differences between physical practice and mental practice gains made by the varsity and junior varsity groups suggested that a certain amount of motor experience was necessary before mental practice provided maximal benefit (11:568).

Smith and Harrison compared the effects of visual, mental, motor, and guided practice on the speed and accuracy of performing a simple eye-hand coordination skill. It was concluded that visual and mental practice improved accuracy on a punchboard learning task; whereas motor practice and guided practice did not (42:307).
Jones investigated the ability of male subjects to learn a gymnastic skill to a pass-or-fail criterion under the conditions of directed and undirected mental practice. The data indicated that subjects were able to learn the skill without demonstration or physical practice and that mental practice without direction was superior to directed mental practice because it allowed the subject to form his own "pattern" (22:267).

Ammons compared eight variations of ocular, manual, and mental practice for their effectiveness in increasing performance on the pursuit rotor after a rest interval and for decreasing the warm-up decrement which occurs after post-rest practice. An analysis of the data showed no significant differences between any of the practice methods in pre- or post-test performance scores (4:191).

Start has led research in the area of the relationship of individual traits to the learning of gross motor skills by mental practice. Two studies by Start attempted to determine the relationship between intelligence and the effects of mental practice on the basketball free throw and on the single leg upstart. In both cases the correlation between the criterion score and the intelligence score failed to indicate a significant difference between the high and low intelligence groups (44:90, 46:649).

In conjunction with the investigation into the
better than the physical practice group. Egstrom also found that the effectiveness of methods varied with the temporal and sequential arrangement of practice and with the level of achievement (54:128). Stebbins found that mental practice was more effective when it preceded, rather than followed physical practice. Stebbins concluded that mental practice alone did not produce any improvement in learning the skill and that a combination of practice conditions appeared to yield the greatest amount of improvement (48:861).

In a survey of the literature in 1962, Harrison stated that mental practice was: (1) an aid to motor learning and proficiency of performance, (2) an aid to retention, and (3) an aid to improved smoothness of performance (18:67). Richardson has recently published a first part of a review of the literature on mental practice in an attempt to investigate the relation of mental practice to performance and to individual differences. His review discussed the value of mental practice on the acquisition, retention, and immediate performance of skills. He cited eleven studies that had statistically significant findings, seven studies that had shown a "positive trend," and three studies that reported negative results. His review developed a tentative conclusion that alternated sessions of mental practice and physical practice are as beneficial as physical practice alone (34:95).
Summary and generalizations

The foregoing literature would appear to support the following generalizations:

1. Mental practice does facilitate the learning of motor skills (11,18,22,34,35,36,42,43). Mental practice is not as effective as physical practice (24,50). Perry and Vandell, Davis, and Clugston (51) reported situations where mental practice was more effective than physical practice (52,51). Three studies have indicated that combinations of physical and mental practice were more effective than either type of practice alone (48,54,55).

2. Several variables in the design of the study which may have influenced the effectiveness of mental practice were: (1) level of past experience, (2) nature of the skill, (3) method of mental practice used, (4) time spent by the mental and physical practice groups, and (5) inadequate statistical analysis of data.

3. Intelligence, imagery, kinesthesis, and games ability have been identified as possible variables influencing the effectiveness of mental practice. Intelligence does not appear to have a significant influence (44:90,46:649). Inadequate measurement of kinesthesis and games ability leaves doubts as to their actual influence. Imagery which is not in control appears to be detrimental to learning by mental practice (47:90).

4. The beneficial effects of mental practice have
been recognized by a few individuals for at least seventy-five years, but there has been an apparent lack of interest in research which would clarify the potential of mental practice in the learning of motor skills. Lack of adequate research has prevented mental practice from being extensively used by physical educators.

5. Mental rehearsal of an activity appears to elicit "below threshold" responses in the muscles employed in the execution of the skill being rehearsed (21:694).

6. Some variables demanding consideration in future studies are: (1) a definition of "mental practice", (2) methods of measuring and directing the learner in the use of mental practice, (3) the most appropriate combination of mental and physical practice, and (4) the stages of learning where mental practice would be most beneficial.

**Literature Related to General Motor Ability**

**Tests and studies supporting the theory of general motor ability**

Much of the research in performance and learning of gross motor skills has centered around the construction, validation, and use of tests of general motor ability. Findings of some of the later investigations tend to support the value and use of tests of general motor ability, while others cast doubts as to their validity. Also included in this section are findings of studies on the relationship between motor ability and learning of new
motor skills and differences between groups of varying motor ability levels in learning motor skills.

Brace devised the first test in physical education designed to measure motor ability in 1927. His definition of motor ability was "...the ability which is more or less inherent, and which permits an individual to learn motor skills easily and to become readily proficient in them" (1:15). His thirty-three item test battery yielded correlations ranging from .47 to .68 between test scores and judges ratings.

Several motor ability tests have been developed for college women. The first, Garfield, set up her test battery to measure speed of voluntary movement, accuracy, steadiness, strength, and capacity to solve motor situations. On the basis of low intercorrelations ranging from .15 to .25, Garfield concluded that the use of the term "general motor ability" was justifiable and that it was possible to investigate the relationship of this group of abilities with intelligence and various special abilities (17:44). Cowdery questioned Garfield's report, contending that the data did not justify the stated conclusion. After further statistical analysis, including the Army Alpha intelligence test, Cowdery stated that there was "definite doubt as to the existence of a distinct motor ability whose coordinated expression is relatively independent of general intelligence" (12:519).
Alden devised a motor ability test for the classification of college women into homogeneous groups. Based on low correlations with the criterion measures ranging from .20 to .72, Alden selected a four-item battery which included the forty-yard maze run, the ball change, trunk bend, and jump and reach. These test items had the highest self correlation, the highest correlation with the composite score, and the highest correlation with the criterion (3:118).

The motor ability test developed by Humiston measures the present status of college women. Fifteen items were selected to represent the criterion measure on the basis of an analysis of the opinions of experts. As a result of statistical analysis it was found that seven items, when used as an index, correlated .81 with the criterion. When the same seven items are administered separately, the validity coefficient with the criterion becomes .92. The test items include (1) a dodging run, (2) sideward roll on the mat, (3) climb over a box, (4) turn in a circle and continue between barriers, (5) basketball throw over a rope, (6) ladder climb, and (7) a twenty-yard straight run (20:18,5). In a later study, Krammeyer found that an adapted version of the Humiston Motor Ability Test resulted in correlations ranging from .69 to .79 with nine skill tests when administered to 125 high school girls and concluded that the test was valid and reliable when used to
classify high school girls (23:315).

Powell selected a motor ability battery for high school girls which included the broad jump, hurdles, scrambles, and velocity throw. The predictive ability of the four-item battery was stated to be about three and one-half times as good as the Rogers indices (33:84). McCloy used total test scores as the criterion for judging general motor ability. He found that track and field events correlated highest with total test scores (26:61).

Scott used the following four criterion items in constructing a test for high school and college women: (1) subjective ratings of sports ability by teachers and students, (2) skill items associated with most common sports, (3) McCloy general motor ability items for girls, and (4) a composite score composed of the above three criteria. As a result of statistical analysis the following items were proposed as a measure of motor ability: (1) obstacle race, (2) basketball throw for distance, (3) standing broad jump, (4) volleyball wall pass, and (5) four-second dash. These items were grouped into three test batteries with correlations ranging from .87 to .91 with the composite score criterion. The reliability of the test items ranged from .91 to .62 (37:83). Broer investigated the reliability of the Scott and Humiston Motor Ability Tests and eight skill tests when administered to junior high school girls. Two administrations of the Scott Test
weighting of strength tests, neither the total strength nor the Physical Fitness Index was a very valid predictor of athletic ability of girls (5:142).

Wellman used grades received in physical education by 170 girls to study the validity of certain tests as measures of motor ability. Physical education grades correlated .53 with Roger's Physical Fitness Index, .35 with Brace's Motor Ability Test, .30 with tests of speed, and .38 with the Burpee test of agility (53:25).

In a study comparing six different methods of scoring tests of physical ability, McCraw and Toblert found the average of three trials, the best of three trials, and the median of three trials yielded the most reliable measure of the subject's ability (29:81).

The construction of motor ability tests was followed by studies conducted to determine the relationship of general motor ability to learning rate in specific activities. Ehrlich using the fencing lunge as the motor skill, found that motor ability, strength, motor capacity and motor educability were not related to rate of learning of accuracy of total bodily movement or speed of movement (14:59).

Hoskins investigated the relationship of tests of general motor ability to learning of specific motor skills. Low correlations were obtained between measures of general motor ability and capacity and attainment of skill in
CHAPTER III
METHOD OF RESEARCH

The problem of this study was to determine whether a subject's level of general motor ability influences the effectiveness of learning a novel motor skill under the conditions of physical practice, mental practice, and a combination of mental and physical practice.

This chapter was divided into the following five sections: (1) a summary of the pilot study, (2) a description of the subjects, (3) a presentation of the experimental design, (4) a description of the apparatus used, and (5) a summary and conclusion of the chapter.

Pilot Study

Prior to the main experiment, fifteen subjects in the sixth grade participated in a pilot study in order to refine the testing techniques and apparatus used in the learning of the novel motor skill. Specifically, the purposes of the pilot study were: (1) to gain more insight into the problem, (2) to develop a novel motor task which would be learned and improved, and (3) to design apparatus and techniques which would provide an administratively feasible means of gathering data from a large number of subjects.

Five subjects in the pilot study participated in
the development of the target. These five subjects were administered the Scott General Motor Ability Test. Two subjects were rated as high in motor ability, two subjects were rated as medium in motor ability, and one subject was rated as low in motor ability.

After the target was developed, the remaining ten subjects practiced the novel skill for five consecutive days. Half of the subjects practiced according to the proposed physical practice method, and the other half practiced the proposed method of combination mental and physical practice. Since the combination practice method included the proposed practice method, a mental practice group was not included in the pilot study.

The ten subjects were tested on the first day, practiced according to their respective methods for three days, and were re-tested on the fifth day. An analysis of the scores on the first and second days indicated that twenty-five trials at ten feet provided a reliable measure of the subject's skill. Changes in performance scores after five days of practice indicated that the subjects' skill improved with practice.

The novel motor skill involved striking a table tennis ball, balanced on a flexible stand, with a wooden paddle held in the non-preferred hand. Subjects attempted to hit the center of a target placed on the wall ten feet away. Complete details of the development of the target
and testing procedures are presented in a following section.

**Selection and Assignment of Subjects**

**Selection of subjects**

The subjects were volunteers attending St. Frances de Sales Catholic School in Sherman Oaks in the fall of 1966. Ninety girls in the seventh and eighth grades were involved in the study.

**Testing of subjects**

The Scott General Motor Ability Test was administered to the ninety subjects. The test battery selected included the dash, basketball throw for distance, broad jump, and wall pass. The directions for administering each test item are given by Scott:

**Instructions**

**Dash**

Running was done down a straight course marked in zone of one yard, each plainly numbered. Subject assumed any starting position she desired; starter, with stop watch, stood near starting line. She gave the signal "Ready," blew the whistle, and at the end of four seconds blew the whistle again. An assistant down the course recorded the zone in which the runner was when the second whistle blew.

**Standing Broad Jump**

Jumping was done indoors, on a marked gymnasium mat, and a beat board used for take off. Instructions were given and practice allowed. Three trials were given and the best used.

**Basketball Throw for Distance**

Subject threw from behind a line, being allowed a running approach if she wished. Instructions were given and practice allowed. Three trials were given and the best used.
Passes--A line was drawn on the floor nine feet in front of a flat wall space. The subject stood behind this line, threw the ball against the wall, caught it and repeated as rapidly as possible for 15 seconds. Instructions and demonstrations were given and a few practice throws allowed. The score was the number of times the ball hit the wall (37:77-79).

These directions were followed as stated with the exception of the beat board on the broad jump which was not employed.

Each subject was placed in ranked order according to the composite T score obtained on the Scott General Motor Ability Test. The top thirty subjects were classified as High Motor Ability, the middle thirty were classified as Medium Motor Ability, and the lowest thirty were classified as Low Motor Ability.

**Grouping of subjects**

Ten subjects in each level of motor ability were randomly assigned to one of three practice conditions. This process involved shuffling the thirty cards for each motor ability level into one of three stacks. The stacks represented physical practice, mental practice, and combination practice. This method of assignment resulted in a standard three by three experimental design. Diagram I illustrates this grouping.

Each of the final groups contained thirty subjects. Each group was given initial instructions and assigned a training schedule. The training schedule for all three
groups is shown in Diagram II.

Diagram I
Grouping of Subjects

<table>
<thead>
<tr>
<th>Motor Ability Level</th>
<th>Mental Practice</th>
<th>Physical Practice</th>
<th>Combination Practice</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Medium</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Low</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
</tr>
</tbody>
</table>

Experimental Design
The experimental design included: (1) a testing procedure, and (2) training programs for the Physical Practice Group, Mental Practice Group, and Combination Practice Group.

Testing procedure
Testing was conducted in the school gymnasium. There were six duplicate sets of testing apparatus, making it possible to schedule a maximum of six subjects simultaneously every ten minutes. Five minutes were spent in testing and five minutes were spent preparing the stations for the next subjects.

The subjects entered the gymnasium and stood in a hallway blocking their view of the testing area. The
subjects were directed to read printed directions which
stated:

You have volunteered to act as a subject in an experi-
ment designed to increase our understanding about the
learning of new sports skills.

I know you have many questions to ask, but I cannot
answer them now. If the experiment is to be a suc-
cess, you must not discuss your part with any other
member of the school.

GENERAL INFORMATION

Each of you are now going to be given a chance to hit
twenty-five ping pong balls at a target on the wall.
You will hit the ball with a wooden paddle held in
your non-preferred hand. A scorer will be recording
your score, so do as best you can. Take one ball at
a time from the box behind the stand, place it on
the stand, and hit it. If you swing and miss, it is
counted as zero.

You will be tested today and on the last day of the
experiment. On the twelve days in between you will
practice the skill according to instructions that you
will receive next time.

Please do not practice outside this room. Remember,
you are not to discuss this experiment with your
friends.

Diagram II

Schedule of Training Periods

<table>
<thead>
<tr>
<th>Days Group</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>Th</th>
<th>F</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>Th</th>
<th>F</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>Th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>T</td>
</tr>
<tr>
<td>Mental</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Combination</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>T</td>
</tr>
</tbody>
</table>

Note: The letter "T" signifies testing, "P" signifies
physical practice, "M" signifies mental prac-
tice, and "C" is combination physical and mental
practice.

After reading the general information, the six subjects reported to an assigned testing station in the gym. The scorer at each station followed the printed instructions on her clipboard. These instructions were:

**Scorers**

1. **The subject may have two practice hits before you begin the scoring on the first and last days of the experiment only.**

2. **Each subject is allowed 25 hits after the two practice shots.**

3. **Subjects are to strike all balls. If the subject swings at the ball and misses, it is counted as zero.**

4. **Each ball should be scored as the ball strikes the target. "Liners" receive the next higher value. If a ball hits outside the target, score it as one (anywhere on the wall).**

5. **Say the score out loud as you record it to see if it agrees with what the subject saw. If there is a disagreement, your score is recorded.**

6. **Do not talk to the subjects about the experiment. Ask them to leave the testing area as soon as they finish.**

7. **Collect 18 balls and place them back in your box, so you are prepared for the next subject. Extra balls are located at the front of the gym. Replace damaged balls.**

An initial score sheet was prepared for each subject. The total score represented the initial ability of the subject before receiving practice.
GROUP A

GENERAL INFORMATION

Practice sessions will be the same as the testing period last time. You will be allowed 25 trials during the practice period. You are not allowed two practice hits during the practice sessions.

The scorer will record the score after each ball is hit. You will hit the ball with the paddle held in your non-preferred hand. Each hit is important so do the best you can. If you swing and miss it will be counted as a zero. Take one ball at a time out of the box and place it on the target stand. After hitting each ball check with the scorer on the score she is recording. Remember the scorers' word is final.

Try to do the best you can each day. Watch where each ball lands and try to hit the ball so it will strike the center of the target.

Please do not discuss the experiment with friends and do not practice outside this room.

Mental practice procedure

Thirty Polaroid sequence photographs were taken of the subjects performing the motor task. The photographs were analyzed by the investigator and three questions calling attention to particular aspects of the subject's performance of the skill were written beneath the photograph. The subjects were instructed to write out answers to the questions each day. The questions required the subject to comment on the head position, the paddle angle, the swing, and the follow through. Both "good" and "poor" form were represented in the photographs. Instructions were attached to a photograph and given to the sub-
subjects each time they reported for a practice session. The photographs were numbered and rotated each day so the subject studied a different form and answered slightly different questions each day. This method of mental practice was employed to increase motivation and to direct the concentration of the subjects for the full five minutes.

GROUP B

General Directions

The term "mental practice" refers to a method of practice which may be useful in learning skills.

For the next twelve days you will "mentally practice" the skill you performed in the testing session yesterday. You are to sit and think about the movement involved in the skill without actually moving any part of your body.

The sequence photograph attached to the page should help you remember the skill. Look at the pictures closely. Read the questions beneath the picture and analyze how the skill is best performed. Notice the good points in the picture as well as the bad points.

The following cues should also serve to aid your thinking:

1. Remember what the paddle felt like in your hand.

2. Imagine yourself swinging at the ball and hitting it off the stand.

3. Try to remember the way the ball traveled through the air in order to hit the target in the center.

Go through the skill as often as possible in the time allowed. Remember, you are competing against the others in the experiment for the highest scores, so concentrate on the skill each day.

Please do not talk about your practice sessions to anyone and do not practice outside this room.
The subjects in the Mental Practice Group reported to a classroom all at the same time each day. They received their instruction sheet and were asked to place it face down until instructed to begin. The session was timed for five minutes by the investigator. Paper and pencils were provided to answer the questions. At the end of five minutes the answer sheets and the photographs were collected and the subjects were excused.

**Combination practice procedure**

The thirty subjects in the combination mental and physical practice group received both sets of instructions with the following changes: (1) the times were changed in both sets of instructions from five minutes to two and one-half minutes; (2) the number of balls scored was twelve, rather than twenty-five.

Subjects in the Combination Practice Group reported in groups of six. They were seated in a hallway blocking their view from the testing area during the mental practice session. The subjects received different instructions sheets each day and answered as many questions as possible during the time allowed. Subjects were timed during their mental practice of the skill for two and one-half minutes.

Instruction sheets were collected immediately and subjects were sent to the testing area. Physical practice consisted of hitting twelve balls each day. Subjects were instructed to leave the testing area as soon as they
finished testing.

Apparatus

The apparatus described in this section was developed in the pilot study. The dimensions of the target were determined in the pilot study and were not changed for the experiment (see Figure 1).

Target

The target used in this study is shown in Figure 1.

Figure 1

The Target
A detailed account of the methods used in the pilot study to develop the target, together with a distance distribution of hits from the aim spot can be found in Appendix A.

The radii of the concentric circles and the assigned point values were: (1) four inches for six points; (2) ten inches for five points; (3) eighteen inches for four points; (4) twenty-eight inches for three points; and (5) thirty-eight inches for two points. The target provided an easy means of scoring the trials in the testing and practice periods. The target was painted on tan paper drop cloth. The circles were painted with black, quick-drying paint. Numbers from one to six were painted in the appropriate area to aid the student scorers. The bottom edge of the target was taped five inches from the gymnasium floor.

**Ball stand**

The ball stand pictured in Figure 2 was developed to provide a means of holding the ball in a stationary, consistent position for striking. The base was made of one inch thick wood, sixteen and a half inches long and eleven and a half inches wide. A one inch diameter wood dowel twenty-eight inches long was nailed to the center of the base, five and a half inches from the end. A spring-type door stop three inches in height was screwed into the top of the dowel to provide a flexible tee. The ball was balanced on top of the rubber tip which had been hollowed out.
Six identical stands were constructed and one placed at each target station.

Figure 2

Ball Stand

---

Paddle

The paddle used in the study was made of one-half inch thick plywood. The face of the paddle was eleven inches long and three inches wide. The handle was four inches long and one inch wide.
Balls

The balls used in the study were regulation table tennis balls. Eighteen balls were placed in a small cardboard box on a bench behind the subject. Subjects reused balls that were convenient to gather in the testing area.

Summary

A pilot study served to develop apparatus and techniques that provided the valid, reliable measurement of the skill used in this study. The novel motor skill consisted of hitting a table tennis ball off a stand with a paddle held in the non-preferred hand at a target placed ten feet away. On the basis of scores obtained on the Scott General Motor Ability Test, the ninety subjects were classified and randomly assigned to one of three practice conditions. The practice conditions consisted of a physical practice group, a mental practice group, and a combination mental and physical practice group. Subjects were tested for initial ability, practiced according to their respective methods for twelve days, and re-tested on the last day.
CHAPTER IV
ANALYSIS OF DATA

Ten subjects in each level of motor ability were randomly assigned to each of three practice conditions, resulting in a standard three by three design. This method of grouping resulted in data which could be analyzed in terms of the effects of the practice treatment, the motor ability treatment, and the interaction of the two treatments. The analysis of variance technique was used to determine the levels of difference between and within groups.

Analysis of variance was calculated to determine whether significant differences existed between the groups as a result of the practice treatment variable, as a result of the general motor ability variable, or as a result of the interaction between the two variables. When significant variance was found to exist, t-test comparisons were used to isolate the source of the differences. The Pearson Product-Moment coefficient of correlation was used to test the reliability of the pre-test and post-test performance scores and the Scott General Motor Ability Test scores. The five percent level of confidence was accepted for all statistical analysis.

The analysis of data was divided into the following
four sections: (1) results of the pre-test, (2) results of the post-test, (3) results of the learning scores, and (4) summary and statement of the findings.

RESULTS OF PRE-TEST

Reliability of student scorers

During the pilot study two student scorers independently scored a subject's performance. Fifty such sets of scores were totaled and correlated to determine the reliability with which sixth grade girls could score the skill used in this study. The resulting \( r \) was .99, supporting the assumption that scoring the skill was not beyond the ability of sixth grade girls.

Reliability of pre-test scores

The reliability coefficient of the pre-test performance scores on the novel skill was determined by the odd-even method of correlation. An \( r \) of .75 was obtained and corrected by the Spearman-Brown Formula to .86. This correlation indicated a strong positive relationship between a subject's pre-test performance score on the novel skill and her initial ability in the skill.

Analysis of the pre-test scores

Descriptive statistics for each of the groups are given in Table 2. The ninety subjects were variously analyzed as three practice treatment groupings and as three motor ability groupings.
The results of an analysis of variance of the pre-test is presented in Table 2. Although there were some differences between the practice groups the analysis indicated that statistically the groups represented the same population.

**TABLE 1**

**DESCRIPTIVE STATISTICS FOR PRE-TEST**

<table>
<thead>
<tr>
<th>Group</th>
<th>Range</th>
<th>Mean</th>
<th>$F_{pre-post}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Practice Treatment Groupings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Practice</td>
<td>32-103</td>
<td>66.13</td>
<td>20.40</td>
</tr>
<tr>
<td>Mental Practice</td>
<td>18-106</td>
<td>67.56</td>
<td>22.46</td>
</tr>
<tr>
<td>Combination Practice</td>
<td>21-100</td>
<td>66.66</td>
<td>17.07</td>
</tr>
<tr>
<td><strong>Motor Ability Treatment Groupings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Motor Ability</td>
<td>39-106</td>
<td>74.76</td>
<td>19.25</td>
</tr>
<tr>
<td>Medium Motor Ability</td>
<td>29-102</td>
<td>69.10</td>
<td>16.77</td>
</tr>
<tr>
<td>Low Motor Ability</td>
<td>18-91</td>
<td>56.50</td>
<td>19.52</td>
</tr>
</tbody>
</table>

The null hypothesis was rejected for the motor ability groups on the basis of pre-test scores. The $F$ value of 8.30 was significant beyond the five percent level of confidence, as shown in Table 2.
In order to determine the source of the differences between the motor ability groups, \( t \)-test comparisons between group means were computed. The results of the comparisons are presented in Table 3.

Table 3 shows the \( t \) values of 3.64 between the High and Low Ability Groups and 2.68 between the Medium and Low Ability Groups were significant beyond the five percent level of confidence. These \( t \) values were responsible for the statistical significance of the \( F \) score. The mean differences between the High and Medium Motor Ability Groups were not significant.

There was an interaction effect on the pre-test significant beyond the five percent level of confidence. Figures 3 and 4 represent the profiles this interaction in terms of the practice treatment effect and the motor ability treatment effect.

### Table 2

**ANALYSIS OF VARIANCE OF PRE-TEST SCORES**

<table>
<thead>
<tr>
<th>Source</th>
<th>ss</th>
<th>df</th>
<th>ms</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice Treatment</td>
<td>31.49</td>
<td>2</td>
<td>15.74</td>
<td>.05</td>
</tr>
<tr>
<td>Motor Ability</td>
<td>5245.45</td>
<td>2</td>
<td>2622.71</td>
<td>8.30*</td>
</tr>
<tr>
<td>Interaction Effects</td>
<td>4347.78</td>
<td>4</td>
<td>1086.94</td>
<td>3.44*</td>
</tr>
<tr>
<td>Within Cells</td>
<td>25580.30</td>
<td>81</td>
<td>315.80</td>
<td></td>
</tr>
</tbody>
</table>

\(* (P < .05)\)
**TABLE 3**

**t-TEST COMPARISONS BETWEEN PRE-TEST MEANS — OF MOTOR ABILITY GROUPS**

| Group   | Mean  | 6 | 6 M | Differences between Group
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groups</td>
</tr>
<tr>
<td>A High</td>
<td>74.76</td>
<td>19.25</td>
<td>3.57</td>
<td>A - B</td>
</tr>
<tr>
<td>B Medium</td>
<td>69.10</td>
<td>16.77</td>
<td>3.11</td>
<td>A - C</td>
</tr>
<tr>
<td>C Low</td>
<td>56.50</td>
<td>19.52</td>
<td>3.62</td>
<td>B - C</td>
</tr>
</tbody>
</table>

*(P < .05)*

**NOTE:** This table should be interpreted as follows: A = High Motor Ability, B = Medium Motor Ability Group, and C = Low Motor Ability Group. The A - B means that the High and Medium Motor Ability Groups had a Mean Difference of 5.66 and a Standard Error of the Difference of 4.69, resulting in a t value of 1.20.
The means for all groupings were computed from the averages of the three sub-groups within each grouping. The mean scores for the practice groups on the pre-test were: 66.1 for the Physical Practice Group; 67.6 for the Mental Practice Group; and 66.7 for the Combination Practice Group. The similarity of the group means resulted in an F value which did not reach statistical significance on the pre-test.

Because the mean pre-test scores of the Medium Motor Ability Group and the Low Motor Ability Group tend to be parallel for all three practice groups, the interaction effect between these groups was not significant. Although the High Motor Ability Group deviates from this
profile, it is not great enough to result in a significant interaction effect.

The significance of the interaction effect on the pre-test appeared to be a function of the motor ability groupings, rather than a result of learning differences. Figure 4 represents the profiles of the means of the motor ability groups. The means vary from 74.7 for the High Motor Ability Group, to 69.1 for the Medium Motor Ability Group, to 56.5 for the Low Motor Ability Group. These mean differences resulted in an F value significant beyond the five percent level of confidence on the pre-test.

The pre-test profiles of the Physical Practice Group and the Mental Practice Group tend to be identical and parallel, indicating a lack of interaction with the motor ability level. However, the Combination Practice Group deviates from this profile and appears to be the group responsible for the statistical significance of the interaction effect on the pre-test.

**Relationship between Scott General Motor Ability Test and beginning success**

A correlation between the subjects' scores on the pre-test and their score on the Scott General Motor Ability Test was computed to determine the relationship between Scott's test and initial success on the novel skill. The resulting r of .47 was significant beyond the one percent level of confidence.
TABLE 5

ANALYSIS OF VARIANCE OF POST-TEST SCORES

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
<th>ms</th>
<th>F</th>
</tr>
</thead>
<tbody>
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<td>Practice Treatment</td>
<td>1492.95</td>
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<td>746.48</td>
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</tr>
<tr>
<td>Motor Ability Treatment</td>
<td>4818.95</td>
<td>2</td>
<td>2409.49</td>
<td>8.38*</td>
</tr>
<tr>
<td>Interaction Effects</td>
<td>2753.92</td>
<td>4</td>
<td>688.48</td>
<td>2.39</td>
</tr>
<tr>
<td>Within Cells</td>
<td>23288.50</td>
<td>81</td>
<td>287.51</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32354.32</td>
<td>89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(P<.05)

t-test comparisons between the means of the motor ability groups were made to isolate the source of the variance on the post-test. The results of this comparison as given in Table 6 show that the High and Medium Motor Ability Groups and the High and Low Motor Ability Groups had *t* values significant beyond the five percent level of confidence. The mean differences between these two groups were responsible for the significance of the *F* value on the post-test. The difference between the means of the Medium and Low Motor Ability Groups did not reach statistical significance.

The relationship of differences between the motor ability groups changed from the pre-test to the post-test. The differences between the High and Medium Motor Ability Groups did not reach statistical significance on the pre-test but did so on the post-test. The differences between
<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>$\sigma$</th>
<th>$\sigma M$</th>
<th>Differences between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groups</td>
</tr>
<tr>
<td>A - High</td>
<td>92.20</td>
<td>14.11</td>
<td>2.62</td>
<td>A - B</td>
</tr>
<tr>
<td>B - Medi</td>
<td>80.60</td>
<td>16.92</td>
<td>3.13</td>
<td>A - C</td>
</tr>
<tr>
<td>C - Low</td>
<td>74.56</td>
<td>21.54</td>
<td>4.00</td>
<td>B - C</td>
</tr>
</tbody>
</table>

*(P < 0.05)*

**NOTE**
This table should be interpreted as follows: A = High Motor Ability Group, B = Medium Motor Ability Group, and C = Low Motor Ability Group. Therefore, A - B means that the High and Medium Motor Ability groups had a Mean Difference of 11.60 and a Standard Error of the Difference of 4.08, resulting in a significant $t$ value of 2.84.
the Medium and Low Motor Ability Groups reached statistical significance on the pre-test but failed to do so on the post-test. This seems to indicate that the High and Low Motor Ability Groups gained proportionately more than the Medium Ability Group during the three-week practice period.

Although the interaction effects were not significant on the post-test, Figures 5 and 6 represent the profiles of means of the groups. The means for the practice groups, as shown in Figure 5, were 82.2 for the Physical Practice Group, 77.6 for the Mental Practice Group, and 87.6 for the Combination Practice Group. These differences were not sufficient to result in a statistically significant F value.

The profiles of the means of the motor ability groups on the post-test as shown in Figure 6 were: 92.2 for the High Motor Ability Group; 80.6 for the Medium Motor Ability Group; and 74.6 for the Low Motor Ability Group. These mean differences resulted in a statistically significant F value of 8.38 on the post-test.

In order to have a significant interaction effect, there should be variability between the means of the groups resulting in overlapping areas between the profiles of the groups. Winer states:

To summarize the implications of the profiles with respect to the three-factor interaction, the latter will be zero when (1) the profiles of the two-factor means are parallel within each of the third factor or when (2) the pattern of profiles for the two-factor means is geometrically similar to the pattern
for the combined levels. In order that patterns be geometrically similar, corresponding profiles must be parallel (2:181)

FIGURE 5
PRACTICE GROUP MEANS ON POST-TEST

FIGURE 6
MOTOR ABILITY GROUP MEANS ON POST-TEST
Figures 5 and 6 indicate some interaction between the two variables, however, the amount of overlapping of the profiles was not enough to result in a significant interaction effect.

**Relationship between Scott Motor Ability Test and final success**

Each subject's score on the Scott General Motor Ability Test was correlated with her post-test performance score on the novel skill to determine the relationship between the Scott test and final ability. The $r$ of .41 was significant beyond the one percent level of confidence and was similar to the correlation obtained on the pre-tests. As with the pre-test, the Scott General Motor Ability Test scores were functional for classifying subjects into performance groups whose final level of ability was statistically different.

**Results of Learning Scores**

**Selection of a learning score**

An analysis of the data was done using gain scores as the operational definition of learning. When no significant differences were found, the validity of using mean gains was questioned.

In 1955, McGraw compared eight different methods of measuring improvement in motor skills in an effort to identify those methods most valid for determining learning
When subjects with different initial scores are being compared, a valid learning score must take into consideration not only gains, but also the difficulty of improvement for subjects with high initial scores.

Total learning score and Percent Gain Possible Score were the only methods that met the validity criteria. Of these, Percent Gain Possible Score was the only method amenable to the data collected in the present study. The score is computed as follows:

\[
\text{Percent Gain Possible Score} = \frac{\text{Sum of Last } N' \text{ minus Sum of First } N'}{\text{Highest Possible Score minus Sum of First } N'}
\]

This learning score compares the actual gain made to the highest gain possible, taking difficulty of improvement into consideration.

**Analysis of Learning scores**

The analysis of variance of the learning scores presented in Table 7 shows that there were no statistically significant differences in learning between any of the experimental groups.

Although there was statistically significant variance between the motor ability groups on the post-test performance scores, an analysis of the learning scores shows that none of the motor ability levels resulted in significantly more learning than the other levels of ability. There was significant variance between the motor ability groups on the pre-test and on the post-test, but this
<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>$\sigma$</th>
<th>$\sigma_m$</th>
<th>Differences between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groups</td>
<td>Md</td>
<td>diff</td>
<td>t</td>
</tr>
<tr>
<td>A - Physical</td>
<td>.1813</td>
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<td>.1915</td>
<td>.036</td>
<td>B - C .128  .052 2.46*</td>
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</table>

*($P < .05$)

**NOTE:** This table should be interpreted as follows: A = Physical Practice Group, B = Mental Practice Group, and C = Combination Practice Group. Therefore, A-B means that the Physical and Mental Practice Groups had a Mean Difference of .0763 and a Difference of .052, resulting in a $t$ value of 1.47.
scores of the experimental groups, all experimental conditions did result in significant learning as evidenced by t-tests comparisons of the pre-test and post-test means. As shown in Table 9, all three practice conditions resulted in statistically significant mean differences when the correlated means of the pre-test and post-test are compared. The t values of 4.48 for the Physical Practice Group, 3.24 for the Mental Practice Group, and 6.86 for the Combination Practice Group were significant beyond the five percent level of confidence.

**TABLE 9**

| $t$-TEST COMPARISONS BETWEEN PRE-TEST AND POST-TEST SCORES OF PRACTICE GROUPS |
|-------------------------------|---------|---------|-----|-----|-----|
| **Group**                      | **Mean** | **Mean** | **d** | **r** | **t** |
| Physical Practice              | 66.13    | 82.20    | 3.32 | .61  | 4.81* |
| Mental Practice                | 67.56    | 77.50    | 3.06 | .70  | 3.24* |
| Combination Practice           | 66.66    | 87.73    | 3.07 | .50  | 6.86* |

*($P \leq .05$)

The comparison between the pre-test and post-test means of the motor ability group is given in Table 10. This comparison shows that all motor ability levels had significant mean gains after three weeks of practice. The t-values of 4.00 for the High Motor Ability Group, 2.40 for the Medium Motor Ability Group, and 3.33 for the Low Motor Ability Group were significant beyond the five
percent level of confidence. Although there were no statistically significant differences between the motor ability groups in the amount of learning, all levels of ability did reveal significant mean differences from the pre-test to the post-test.

**TABLE 10**

**t-TEST COMPARISONS BETWEEN PRE-TEST AND POST-TEST SCORES OF MOTOR ABILITY GROUPS**

<table>
<thead>
<tr>
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<th>Mean pre</th>
<th>Mean post</th>
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<td>Low Motor Ability</td>
<td>56.60</td>
<td>74.56</td>
<td>5.39</td>
<td>3.33*</td>
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</tbody>
</table>

*(P .05)

The interaction effects between the practice treatments and the motor ability levels did not reach statistical significance on the basis of the learning scores. Although none of the differences were significant, Figures 7 and 8 present the profiles of the learning score means of the practice groups and the motor ability groups.

The learning score means for the practice groups shown in Figure 7 were: 1.81 for the Physical Practice Group; 1.05 for the Mental Practice Group; and 2.33 for the Combination Practice Group.
Subjects ranked as high in motor ability, practicing under the combination practice conditions, had the highest learning score, although the differences between motor ability levels were not statistically significant. Under the mental practice conditions, the High Motor Ability Group appeared to benefit least, while the Medium Motor Ability subjects gained the most.

Figure 8 represents the profiles of learning score means of the motor ability groups. The High Motor Ability Group had a gain of 1.97, the Medium Motor Ability Group had a gain of 1.36, and the Low Motor Ability Group had a gain of 1.86. The differences between the learning score means of the motor ability groups were not statistically significant.
the test scores to predict learning ability.

Summary

Data were analyzed in terms of the results of the pre-test, the post-test, and the learning scores. Motor ability effects, practice treatment effects, and interaction effects were determined by analysis of variance techniques. Correlations were used to determine the reliability of the performance scores on the novel skill and the relationship between these performance scores on the novel skill and the Scott General Motor Ability Test scores. The analysis of variance technique determined if any statistically significant variance existed between the groups; and when such variance did exist, t-test comparisons were used to identify the source. The interaction effects of the two variables were represented in profiles of the group means.

As a result of this analysis, the following findings were made:

1. The scorers were reliable ($r= .99$).
2. The pre-test scores had a reliability of .86 as a measure of initial ability.
3. The practice groups statistically represented the same population on the pre-test.
4. There was significant variance between the motor ability groups on the pre-test as a result of the significant mean differences between the High and Low Motor
Ability Groups and the Medium and Low Ability Groups.

5. There was an interaction effect significant beyond the five percent level of confidence on the pretest as a result of the motor ability groupings.

6. There was a correlation of .47 between the Scott General Motor Ability Test and the post-test performance scores.

7. The reliability of the post-test performance scores as a measure of final ability in the novel skill was .85.

8. The F value of 2.60 for the practice treatment conditions failed to reach statistical significance.

9. The motor ability groups had a significant F value of 8.38 on the post-test.

10. t-test comparisons showed that the source of the differences between the motor ability groups was a result of the significant differences between the High and Medium Motor Ability Groups and the High and Low Motor Ability Groups.

11. The interaction effects were not significant on the post-test because the profiles of the group means were too parallel.

12. Percent gain possible score is a valid learning measure for the type of data collected in the present study.

13. No significant variance between any of the experimental variables existed on the learning scores.
14. *t*-test comparisons between the learning scores of the practice groups showed that learning differences existed between the Mental Practice Group and the Combination Practice Group, in favor of the Combination Practice Group. No learning differences were found between the physical practice method and the mental or combination practice methods.

15. Correlated *t*-tests between the pre- and post-test means of the practice groups showed significant mean differences beyond the .05 level of confidence for all three groups.

16. The results of *t*-test comparisons between the pre- and post-test means of the motor ability groups showed statistically significant mean differences for all three ability groups.

17. There was a low, insignificant correlation of .07 between the Scott General Motor Ability Test scores and the learning scores.
Chapter V is divided into six parts: (1) differences between the practice treatment groups in the learning and performance of a novel motor skill; (2) the differences between motor ability groups in the learning and performance of a new motor skill; (3) the interaction effects between level of motor ability and practice treatment condition; (4) summary of findings and conclusions; (5) implications for physical education teachers; and (6) recommendations for further study.

**Differences Between Practice Treatment Groups in the Learning and Performance of a Novel Motor Skill**

One of the problems of this study was to determine whether there was a statistically significant difference between physical, mental, or a combination of mental and physical practice in the learning of a novel motor skill.

$t$-test comparisons of the pre-and post-test means of the practice groups revealed that all practice conditions resulted in statistically significant mean gains after three weeks of practice. That physical, mental and combination practice are effective has been supported by a
majority of studies in this area (11, 18, 22, 35, 43, 50, 51, 54, 55). Since all practice conditions resulted in significant performance increases, an analysis of the differences between groups was of particular concern to this investigator to determine if any one method of practice resulted in statistically greater performance or learning gains.

Analysis of variance of the performance and learning scores of the practice groups revealed no significant differences between the groups. Since analysis of the learning scores resulted in an F value of 3.00 which came close to reaching the 3.11 for statistical significance, t-test comparisons between the learning score means of the practice groups were computed. This analysis revealed learning differences between the combination and mental practice groups in favor of the Combination Practice Group.

The majority of literature in the area of mental practice has shown physical practice to be more effective than mental practice for improving motor skills (11, 24, 49, 50, 55). However, Perry (32) and Vandell, Davis, and Clugston (51) have reported that, under some conditions, mental practice may be as effective as actual physical practice. Under the conditions of this study, there were no statistically significant differences between the
Physical Practice Group and the Mental Practice Group. The lack of significant learning differences between the mental and physical practice groups can be examined in terms of the success of the mental practice treatment or in terms of the failure of the physical practice treatment.

There are several possible explanations for the success of the mental practice treatment. One explanation concerns the method of conducting the mental practice sessions. This study made a concentrated attempt to direct and control the mental practice sessions. Looking at the sequence photograph and writing answers to the questions served to direct the concentration of the subjects to the mental practice of the skill. The sequence photographs were rotated daily, providing the subjects with a new problem to analyze each day. This method minimized boredom and drifting of attention which could weaken the quality of the practice session and be reflected in lower scores on the post-test.

Since each subject learns as a unique individual, the type of stimulation used to motivate activity must be meaningful to the learner. Therefore, it would appear to be advantageous to provide a wide variety of stimuli from which the subject may choose. In the present investigation the sequence photograph provided visual stimulation, writing answers to the questions was a form of tactile stimulation, and reading the performance cues aloud each
day provided audial stimulation.

In addition to the method of conducting the mental practice sessions, motivation may have played a role in the success of the Mental Practice Group. The general directions for the group contained the phrase "you are competing against others in the experiment for the highest scores..." The subjects were lead to believe that their written answers were being read by a panel of college professors and urged to give careful thought to their answers. The subjects were also reminded by the investigator that their mental practice sessions were the only practice they would get before the final testing period and to concentrate the full time each day. In discussions with the investigator the subjects indicated they were excited about being in an experiment, curious to see if "thinking really worked," and determined to get the highest scores. The design of the study made no provision for the measurement of motivation; therefore, there is no way of determining what actual effect, if any, motivation had on performance.

The nature of the skill may have also played a part in the success of the mental practice group. The possibility exists that the nature of skill effects the subjects' ability to benefit from mental practice. Investigations in the area of mental practice have often selected the basketball free throw or a gymnastic-type skill because
these activities appear to be amenable to mental practice. Perry concluded that the relative efficiency of imaginary and actual practice varies with the test used (32:75). The ball hitting skill used in the present investigation may have been particularly amenable to improvement by mental practice. Change in performance scores provide a measurement of the ability to benefit from mental practice of a skill. Since there was a significant increase in the performance scores after mental practice, it appears reasonable to assume that the motor skill used in this investigation was susceptible to improvement by mental practice.

Failure of the physical practice conditions to result in greater performance increases was also mentioned as a possible reason for the lack of differences between the mental and physical practice groups. There appear to be at least two possible explanations for the lack of greater performance gains by the Physical Practice Group. One reason pertains to the nature of the skill and the other to the attitude of the subjects.

Subjects in the Physical Practice Group who scored high during the first day of practice cannot be expected to gain as much through practice as subjects making a lower score. A question arises as to whether the nature of the skill prevented the high scoring subjects from attaining better scores during the later stages of practice. During
the first week of practice, ten subjects in the Physical Practice Group scored over 100 points out of a possible score of 120. These high scores during the early stages of practice made it difficult to improve performance significantly. There is a possibility that the Physical Practice Group may have achieved higher mean scores had the skill not contained limits to performance and improvement. It was recognized before initiation of the experiment that the skill contained structured limits to increasingly improved performance; however, it was not anticipated that limits would be such an easily attainable goal for so many subjects.

Attitude of the subjects was also mentioned as a possible explanation for the failure of the Physical Practice Group to make greater performance gains. Although the high scoring subjects continued to compete for better scores, reports from several subjects in discussion with the investigator indicated they had difficulty concentrating on each ball hit, each day. There seemed to be an attitude among these subjects that if one ball was missed or scored low it did not make much difference because there were ample chances. Some subjects reported they found the repetitive nature of the skill boring and lost interest. Subjects who repeatedly scored low indicated a defeated attitude and appeared to "give up." Lack of data measuring motivation prevents generalizations
concerning the effects of motivation in this study; however, motivation is a concept that warrants consideration in any discussion of motor performance and learning.

_t_-test comparisons between the learning scores of the practice groups indicated a learning difference between the Combination Practice Group and the Mental Practice Group in favor of the combination practice conditions. Several investigations (48,54,55) have indicated that combinations of physical and mental practice were more effective than either type of practice alone.

The combination practice method would appear to contain the best elements of mental practice and physical practice methods, while eliminating some of the less desirable elements. The two and one-half minute mental practice session required the subjects' full concentration in order to analyze the photograph and write answers to the questions in the allotted time. Subjects indicated to the investigator that the mental practice session provided them with a favorable "set" for the physical practice session. Unlike the Mental Practice Group, subjects in the Combination Practice Group were able to test their "theories" with immediate knowledge of results. Since the combination practice sessions consisted of hitting twelve balls rather than twenty-five, it may be possible that the subjects had a greater desire to "make each ball count."
Differences Between Motor Ability Groups
in the Learning and Performance
of a Novel Motor Skill

One of the purposes of this study was to determine whether differences existed among the three levels of motor ability, classified on the basis of scores obtained on the Scott General Motor Ability Test.

Analysis of variance revealed statistically significant performance differences between the motor ability groups on the basis of pre-and post-test scores on the novel skill. t-test comparisons were computed to isolate the source of the differences. Statistically significant differences were found between the High and Low Motor Ability Groups on the pre-and post-test performance scores. The differences between the High and Medium Motor Ability Groups and the Medium and Low Motor Ability Groups were not consistent from the pre-test to the post-test.

The differences between the High and Low Motor Ability Groups may be explained in terms of the differences in initial ability. Superiority of the High Motor Ability Group for performing a novel motor skill showed on the pre-test and continued throughout the experiment. Although all subjects had the same opportunities for learning the skill under their respective practice conditions, the findings indicate that the early superiority exhibited by the High Motor Ability Group was not diminished by the effects of practice.
The performance differences between the High and Medium Motor Ability Groups and the Medium and Low Motor Ability Groups were not statistically significant in all instances. Under the conditions of this study, the most logical explanation appears to rest in the classification of motor ability groups. Subjects were classified into motor ability groups on the basis of composite T scores on the Scott General Motor Ability Test. Subjects were ranked from one to ninety on the basis of test scores and divided into three groups of thirty. Identical scores fell above and below the division lines, resulting in an overlapping of ability between the high and medium ability groups and between the medium and low ability groups.

It is also possible that the Scott General Motor Ability Test is not reliable for distinguishing between discrete levels of ability. Therefore, the determination of motor ability levels was limited by the validity and reliability of the Scott General Motor Ability Test. The test items included in the Scott test were only administered once, further limiting the validity of the motor ability groupings. More reliable motor ability groupings might have been obtained if the test items would have been administered more than once. Under the conditions of this study, the Scott General Motor Ability Test had validity for classifying the extremes of motor ability into homogeneous performance groups.
Lack of consistent statistical differences between the high and medium ability groups and between the medium and low ability groups may also be due to the degree of difficulty of the skill. Easier skills may suffice to distinguish between the extreme levels of ability, but not between the medium levels. A more difficult skill may have distinguished between the High and Medium Motor Ability Groups and the Medium and Low Motor Ability Groups, as well as between the High and Low Motor Ability Groups. The influence that the degree of difficulty of the skill had on the performance and learning scores was not measured in this study. The effects that the difficulty of the skill had on performance may be more specific than general.

Analysis of variance of the learning scores revealed no statistically significant differences between any of the ability groups in the amount of learning that took place. Also, an insignificant correlation of .07 was obtained between the learning scores and the Scott General Motor Ability Test scores. On the basis of this finding, it would not appear justifiable to use scores on the Scott Test to predict learning ability in novel skills. Richardson cites a study by Start that also found an insignificant correlation between gain scores and the Brace Motor Ability Test (34:105). On the basis of a factor analysis of motor learning, McCraw concluded that the
constituents involved in learning a novel skill were separate and distinct from those of athletic or motor ability (27:335). However, research in the validity of using motor ability test scores to predict future learning ability is contradictory. Stephenson (56:34) and Snell (57:36) reported significant correlations between the Scott Test and measure of learning. Richardson cites Whiteley as reporting a significant relationship between percent gain and the Iowa-Brace Test (34:105). The findings of this study support the use of the Scott General Motor Ability Test for classifying students into homogeneous ability groups whose performance level will be different, but do not support the use of the Scott Test to predict learning ability in the novel skill used in this study.

Interaction Effects Between Level of General Motor Ability and Practice Treatment Conditions

Analysis of variance showed a lack of statistically significant interaction between level of general motor ability and practice treatment conditions on the basis of performance scores on the post-test and learning scores on the novel skill. On the basis of these findings, the null hypothesis of no significant differences was accepted at the five percent level of confidence. A possible explanation for the lack of a statistically significant
interaction effect is that subjects reacted individually to the treatment conditions; thereby increasing the variability within groups and decreasing the significance of differences among groups.

A particular concern of this study was to determine if a subject's level of motor ability influenced the ability of the subject to gain maximal benefit from mental practice. Under the conditions of this study, level of motor ability did not appear to be a variable influencing the benefit gained from mental practice. Although none of the differences were significant the Medium Motor Ability Group had the greatest learning gain under the conditions of mental practice, while the High Motor Ability Group had the least gain. This finding is not in agreement with an early study by Start which concluded that subjects rated as high in games ability were responsible for the significance of the gain made by the mental practice group (43:173); however, it does agree with a later study by Start cited by Richardson, in which an insignificant correlation was found between motor ability test scores and mean gain scores (34:105).

Summary of Findings and Conclusions

Based on the analyses and discussion of the data the following findings appear to be justified:

1. There were no statistically significant
differences between the three practice conditions on the basis of learning and performance scores on the novel skill.

2. There were statistically significant differences in performance between the High and Low Motor Ability Groups on the learning of the novel skill.

3. There were no statistically significant differences between the motor ability groups in their ability to learn the novel skill on the basis of percent gain possible score.

4. All experimental conditions resulted in statistically significant mean differences on the novel skill from pre-test to post-test.

5. The interaction between general motor ability level and practice treatment conditions failed to result in statistically significant differences between performance scores on the post-test and learning scores on the novel skill.

Based on these findings it was concluded that: (1) the Scott General Motor Ability Test has validity for classifying subjects into performance groups, but not for predicting learning differences, and (2) the interaction between level of motor ability and practice treatment failed to result in statistically significant differences in performance or learning between groups.
Implications for Physical Educators

Since research supports the thesis that mental practice is not harmful to the learning of motor skills and many investigations have supported its beneficial effects, physical educators should give consideration to employing mental practice as a teaching method to a greater extent. The findings of the present study support the use of mental practice in all levels of motor ability.

Recommendations for Further Study

The findings of this study appear to have implications that bear further investigation. The following are some suggested areas of possible research:

1. There was a lack of statistically significant interaction between general motor ability and practice conditions with ninety subjects. Further research needs to investigate whether increasing the number of subjects in each group would effect the statistical significance of the data.

2. There is some question as to whether similar results would be obtained if students of a different age level were selected as subjects. A suggested area of research would be to conduct the same experiment with high school subjects.

3. Since the novel skill used in the present study involved motor learning, the ability of subjects with
different levels of motor educability to benefit from mental practice still needs to be investigated.
BIBLIOGRAPHY
BIBLIOGRAPHY

Books


Periodicals


Unpublished Material


Other Sources
58. Personal interview with Dr. Glen Egstrom, University of California, Los Angeles, California, December 10, 1966.
APPENDICES
APPENDIX A

Development of Target Distance Distribution of Hits from Aim Spot

<table>
<thead>
<tr>
<th>Distance from center in inches</th>
<th>Number in Interval</th>
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The five subjects who participated in the development of the target were given the same instructions used for the initial testing in the main experiment. The
subjects were asked to hit twenty-five practice balls each day for four days using the novel motor task used in the study. Four practice sessions were allowed before the measurements were taken to account for rapid, initial learning; thereby making the target a better representation of skill. The subjects were requested to aim at a black spot arbitrarily located at a height of five feet. On the fifth day, each subject was allowed to hit two practice balls. The place where the next ten balls struck the wall was marked as accurately as possible by the investigator. The distance of each of the fifty marks was measured from the center of the spot on the wall and recorded to the nearest half inch.

The data were cast into a frequency distribution and an accumulated percentage was calculated for each interval. The percentage area was divided into six sections resembling a normal distribution. These areas were assigned point values ranging from six points in the innermost circle to two points in the outermost circle. One point was given to any ball reaching the wall outside the target. If the subject swung and missed, it was scored as zero.
APPENDIX B

RAW DATA OF SUBJECTS

Column A - Number of Subject
Column B - Subject's score on Scott General Motor Ability Test
Column C - Subject's score on the pre-test
Column D - Subject's score on the post-test
Column E - Subject's learning score

<table>
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<tr>
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