THE EFFECT OF FOUR DIFFERENT CONDITIONS OF MENTAL PRACTICE ON THE PERFORMANCE OF BEGINNING AND INTERMEDIATE BOWLERS

THESIS

Presented to the Graduate Council of the North Texas State University in Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

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August, 1979

Reading, Rosemary, The Effect of Four Different Conditions of Mental Practice on the Performance of Beginning and Intermediate Bowlers. Master of Science (Physical Education), August, 1979, 69 pp., 4 tables, references, 38 titles.

This study investigated the effects of four different types of mental practice (free imagery, directed visual, directed reading, and directed audio) on the performance of 45 beginning and 40 intermediate college bowlers. The groups bowled six games with two sets of five minutes of mental practice prior to the first frame and the sixth frame of each game. Data were analyzed by a two-way analysis of variance with repeated measures. No significant differences existed between treatment groups at either the beginning or intermediate levels. Conclusions were that no one technique of mental practice was more effective than another in increasing bowling performance.

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CHAPTER I

Introduction

Physical educators frequently have limited their methods of teaching motor skills to the predominant use of physical practice techniques. It is probable that the explanation for this common idea results from the concept that the learning of skills is reflected in observable behavior expressed through physical performances and physical drills. In addition, motor tasks are initiated, developed, and refined during specified stages of acquisition and the degree of learning is inferred from the overt performance. Evidence exists, however, which suggests that physical proficiency might be considerably enhanced by inclusion of a variety of learning techniques such as mental rehearsal, observation of another's performance, informally thinking about the task, reading material, viewing films, or mental imagery (Oxendine, 1968; Singer, 1975). Consistently, results from investigators have indicated that mental practice is beneficial to physical performance at all skill levels, but especially to intermediate and advanced performance (Clark, 1960; Oxendine, 1968; Singer, 1975). Therefore, physical educators have begun to incorporate

a combination of physical and mental practices to promote an increase in skill development.

A problem arises, however, for the teacher who attempts to employ physical and mental practice sessions in his or her teaching strategy. According to Richardson (1967), the majority of mental practice studies have focused upon the facilitating effect of mental practice on the acquisition, retention, and overall improvement of a motor skill rather than identifying the best possible type of mental practice. Thus, there is a need for more specific guidance in order to enable the individual to use mental rehearsal for effective learning and performance.

By identifying and determining the most beneficial methods of mental practice, teachers could gain additional methodologies to be used in class. Likewise, they could use these techniques of mental practice to provide for environmental situations which enhance physical proficiency. It is intended that teachers and participants involved in physical skill activities will employ mental practice as an extra dimension and not as a substitute for overt practice.

It seems reasonable to suggest that if research supports the use of mental practice and if teachers are expected to guide and direct students in "how" to use mental practice, an effort must be made to narrow the

selection and types of mental practice which are most beneficial in increasing the level of physical performance. Current models used in mental practice must be identified and tested for their effectiveness in promoting skill development. Futhermore, it is necessary to determine if specific types of mental practice are equally useful at different levels of physical performance.

Statement of the Problem

This study was designed to investigate the effect of four different types of mental practice on the performance of beginning and intermediate bowlers.

Purposes

The purposes of this study were:

1. To determine the influence of free imagery, directed reading, directed visual, and directed auditory techniques as different types of mental practice on skill performance of beginning bowlers;

2. To determine the influence of free imagery, directed reading, directed visual, and directed auditory techniques as different types of mental practice on the skill performance of intermediate bowlers.

Definition of Terms

The following terms and definitions were used in this study:

1. Mental Practice (theoretical).--"Mental or image practice or conceptualization refer to task rehearsal [of a physical practice] in which there are no observable movements" (Singer, 1975, p. 386);

2. Mental Practice (operational).--Practice of an activity by way of mental processes, such as thinking, symbolic relationships, and visualizations;

   a. Free Imagery Technique (operational).--The subjects are asked to think about and see themselves performing the designated bowling skill;

   b. Directed Visual Technique (operational).--The subjects view a film of the designated bowling skill and then are asked to imagine themselves performing the prescribed skill like the bowler in the film;

   c. Directed Reading Technique (operational).--The subjects read and interpret a detailed written outline of the designated bowling skill and then are asked to imagine themselves performing the prescribed skill;

   d. Directed Audio Technique (operational).--The subjects listen to the taped sounds of the designated bowling skill and then imagine themselves performing the prescribe skill while reproducing the sounds;

3. Physical Practice (operational).--Practice of an activity through physical or observable behavior;

4. Beginning Male Bowler (operational).--Any male bowler who has a bowling average of 132 or below;

5. Beginning Female Bowler (operational).--Any female bowler who has a bowling average of 114 or below;

6. Intermediate Male Bowler (operational).--Any male bowler who has a bowling average of 133 or above;

7. Intermediate Female Bowler (operational).--Any female bowler who has a bowling average of 115 or above.

Delimitations of the Study

This study was delimited to subjects, both male and female, who met the established criteria for performance techniques related to type of approach, delivery, point of aim, and bowling averages. Futhermore, subjects bowled on fifteen different lanes rotating within their treatment groups.

Limitations of the Study

This study was limited in that the classes met on different days and at different times. In addition, the subjects were selected from the students enrolled for the beginning and intermediate bowling classes at North Texas State University during the spring semester, 1979.

Summary

Many investigators have emphasized the positive benefits derived from combining mental practice techniques with physical practice when performing motor skills. In retrospect, it seems necessary to identify from existing models which technique or techniques are most beneficial to the performer. This investigation, therefore, was conducted in an attempt to ascertain the effects of different mental practice techniques in bowling and to determine if there were differences in the use of varied forms of mental practice for beginning and intermediate bowlers.

CHAPTER II

Review of Literature

An extensive review of the literature revealed a limited number of research studies that directly identified the methods of mental practice best suited for increasing skill performance. The majority of the studies were concerned with the effectiveness of mental practice combined with physical practice. Richardson (1967) stated that "investigations into the process of mentally practicing a perceptual motor skill began 30 years ago. However, there has been a marked increase in the amount of interest in this area of research in the last ten years" (p. 95). Cratty (1968) suggested that difficulties have arisen in studying mental practice because of the investigators' inabilities to control the thinking of subjects. For example, are the subjects actually attending to the specific task and the specific method of mental practice requested by the researcher? Studies investigating these difficulties and others will be included in the review of literature in order to formulate a better understanding of the concepts related to mental practice.

Organization of Studies

Research studies concerned with mental practice, both early and recent, have emphasized different organizational patterns. Oxendine (1968) has cited the organizational processes for the early studies. Two or three groups were equated on a new skill. Following the homogeneous grouping of all performers by skill, the main group was divided into a group involved in a physical practice schedule, a second group involved in a mental practice schedule, a group which used a combination of physical and mental practice, and a control group.

Criteria or variables for present-day investigations were listed by Singer (1977). They included skill level, novelty of the task, intelligence of the performer, the performer's kinesthetic sensitivity, and relationships between amounts of physical practice compared to mental practice.

Likewise, the investigations conducted by Fleishman and Hempel (1954; 1955) are important to the concept of mental and physical practice. The objectives of the experiments were to identify through factor analysis of performance the complexity of motor tasks, changes in stabilization of factors, and the importance of "motor" versus "non-motor" factors at the early and late stages of practice. Factors specific to physical performance

were recognized. The list included psychomotor coordination (motor), rate of movement (motor), spatial relation (non-motor), perceptual speed (non-motor), psychomotor speed (motor), visualization (non-motor), mechanical experience (non-motor), and numerical facility (non-motor). The investigators concluded that the abilities that contribute to proficiency early in learning are not necessarily those which contribute to proficiency at later stages. Non-motor factors were particularly important during initial and early stages of learning while motor factors increased proficiency of the skill later in learning. Thus an understanding of the task, perceptual qualities, and spatial characteristics emerged as essential factors in the initial development of skill. Introspective or mental practice would facilitate the acquisition of skill if those factors were emphasized. Motor factors were paramount to skillful performance in late and final stages of learning. Consequently, a learning set and practice which result in a physical habit would appear to be possible benefits gained from covert rehearsal of the task.

There are many theoretical positions given for the effectiveness of mental practice. Jones (1965) stated, "it may be that physical practice, which in the past has been deemed so important, is only concerned with the

refinement of movements and that the major part of the mastery of an action is a central process, not a peripheral one" (p. 270). This hypothesis would imply that mental practice is the foundation for physical practice and that time must be given to this phase of the learning process. Another interpretation is offered by Sage (1977). He suggests that when performers mentally think and picture themselves performing a task, they are simultaneously transmitting neural impulses to the brain. He further states that although mental practice is not physical in its outward appearance, it inwardly characterizes a physical appearance in that the nervous system is sending out electrical currents through the body cells. Both of these theories would suggest that mental practice operates on an internal basis in which the mental processes prime the neural and muscular systems to a level of activity just below that of overt physical actions.

Comparison of Mental Practice to Physical Practice

A major area of mental practice which has been thoroughly investigated compares the effects of mental practice with that of physical practice. One of the first studies to attempt to isolate the effects of mental practice in the learning of a motor skill was conducted by Vandell, Davis, and Clugston (1943).

This was a classical study because few experiments prior to this time had dealt with the mental aspect in relationship to motor activity.

The subjects in the study were males chosen from three age-grade levels in junior high school, senior high school, and college. The subjects were selected and equated by a series of standardized tests which included intelligence, educational age, chronological age, motor ability, and physique (height, weight, growth, eyes). Thus, subjects were chosen who approached normality on all equating factors or who were "average" on items. The motor tasks for the experiment were dart-throwing and free-throw shooting. Subjects were divided into the following three groups:

1. Group I - actual physical practice trials on the first and 20th days with no directed practice of any kind between those days;
2. Group II - actual physical practice trials on each of the 20 days;
3. Group III - actual physical practice trial on the first and 20th days and mental practice periods from the second through the 19th.

The investigators concluded that systematic "mind rehearsal" of a motor activity does exist; mental practice is a contributing factor in motor activity; and mental practice is almost as effective as physical practice in promoting skill performance.

Twining (1949) initiated a study to examine the difference between physical practice and mental practice when learning a motor skill (ring tossing). One group threw 210 rings on the first and 22nd days while receiving no mental practice; one group threw 210 rings on the first day, 70 rings on the second through the 21st day, and 210 rings on the 22nd day; and a third group received a combination of throwing 210 rings on the first day, mental rehearsal of the original task for 15 minutes daily on the second through the 21st day, and 210 rings on the last day. The results of the study were that both mental and physical practice were beneficial in promoting the learning of a motor skill. Furthermore, it was reported that a subject's concentration floundered in mental practice after approximately five minutes.

Other studies have sought to identify the effects of mental practice upon physical performance. Clark (1960) examined cause-effect relationships of arm strength and intelligence as well as varsity, junior varsity, or novice experience. The subjects were tested on the Pacific Coast one-hand foul shot. The methods used to promote mental practice were twofold. First a printed information sheet on the technique for shooting the one-hand foul shot was given to subjects. Secondly,

the instructor gave them instructions (without a basketball) in the shooting technique. During this practice the students were urged to recognize the specific motions involved; to see or view themselves or their instructor performing the successive motions; and to close their eyes and try to feel the sensations of performing the task. Results of the study indicated a positive effect of mental and physical practice on skill acquisition, no significant differences in levels of intelligence and the ability to use mental practice, an increase in subjects' abilities to adapt to visual and imagery techniques, and finally, a greater degree of effectiveness in mental practice at the higher skill level.

The results of Start's (1962) research also supported the principle that performers with higher skill levels benefited more than their lesser skilled counterparts when using mental practice. Similarly, Whitely (1962) found that subjects with high motor ability scores profited more from mental practice than subjects with low motor ability scores on games ability such as ball throwing.

Additional models of inquiry have yielded information which supports 1) the facilitation of physical skill by mental practice in activities such as wand-juggling,

throwing a ball at a target, and tennis (Corbin, 1967; Stebbin, 1968; Wilson, 1961), and 2) the need for physical performance prior to mental practice to gain total effectiveness (Moody, 1967; Phipps & Moorehouse, 1969; Stebbins, 1968). Further, the investigation conducted by Smyth (1975) using a mirror-drawing task substantiated the benefits gained when mental practice was preceded by physical practice.

Oxendine (1969) studied the relationships of mental and physical performances using three different motor skills including the pursuit rotor, soccer kick for accuracy, and the modified basketball jump shot. From the stated conclusions, three appear to be of major importance: (a) the combination of physical and mental practice performed under designated amounts of practice time can be as effective in learning a motor task as that of physical practice alone, (b) mental practice is not dependent upon the levels of intelligence which the subjects possess, and (c) fifty per cent of the practice time in mental practice can be as useful as 100% of the time in physical practice when the motor task is in the range of the subjects' learning abilities.

Another study related to the underlying effect of intelligence was conducted by Start (1960). The study investigated the effect of mental practice and

intelligence of performance upon free-throw shooting skills. It was concluded that no significant relationship existed between intelligence and mental rehearsal of the task.

Studies have not only compared mental practice with skill acquisition, but they have identified its use in priming the muscular system. Kelsey (1961) stated "that muscular endurance can be increased through a mental rehearsal of a particular item of endurance, and that the increase would be as great or greater than through physical practice" (p. 47). He found that mental practice increased endurance in the abdominal and thigh flexor muscles, but physical practice got the best results. Another study concerning the effects of mental practice on muscular involvement was conducted by Schick (1970). College women were selected to perform a variety of volleyball skills. It was reported that mental practice was not beneficial on the wall volley. The subjects did learn, however, to visualize and feel the movements associated with the skill.

Although most of the studies in mental practice have yielded positive findings, several have reported no significant effects from the use of mental practice, and some have suggested negative results obtained from the use of imagery. Singer and Witker (1970) using

a pursuit rotor skill suggested that no benefits in performance were gained from mentally rehearsing the task. Trussell (1958), however, concluded that mental practice produced a decrement in physical performance. The mental practice groups which performed a ball juggling task did not improve significantly and mental practice was not effective until combined with physical practice.

Techniques for Mental Practice

According to Sage (1977), mental practice may be promoted by having learners focus their attention on the task and imagine or visualize themselves executing the correct movement pattern or by a performer rehearsing game tactics between contests or even during lulls in a contest. Few investigators, however, have attempted to specifically identify methods of mental practice.

Smith and Harrison (1962) compared visual, motor, mental and guided practice upon speed and accuracy of performing a simple motor task. The researchers hypothesized "that different visual, as well as non visual factors determine the learning of a simple eye-hand coordination task" (p.300). Sixty college males performed a stylus-type punchboard test. Six treatment groups of ten subjects each were used. Each subject

was tested on his ability to perform the task of placing a metal stylus in the three equally distant holes under various practice conditions. The treatment groups were motor technique, visual, reversed-visual, mental, guided, and a control group. Preceding the test, instructions and directions were given and included the following information: (a) a one-minute test will be given to establish original skill level on the punchboard; (b) errors will be visually calculated; and (c) mechanical counters connected to the target will record correct hits. After the initial test, specified instructions and procedures were provided for the following groups:

1. Motor Practice technique - This group physically performed the task for ten seconds and then relaxed for ten seconds by reading about the task. This procedure continued in sequence for six minutes of total time or a breakdown of three two-minute periods;

2. Visual Practice technique - This group visually practiced the skill in the same manner as if performing it physically. The time element was identical to that of the motor practice group;

3. Reversed Visual technique - This group followed the same procedures as the visual group, however, subjects had to visually reverse the direction of completing the cycle;

4. Mental Practice technique - Subjects in this group closed their eyes for ten seconds while they mentally reviewed the task. This was followed by ten seconds of strict instructions to read about the task, thereby guarding against further mental rehearsal;

5. Guided Practice technique - Subjects in this group also had their eyes closed, however, they were directed through the task by the instructor in order to develop a sense of feeling for the movement. This technique was followed by ten seconds of reading;

6. Control technique - This group read during the entire two minutes between physical performance. All groups performed the physical skill after each two minute treatment.

In analyzing the data, Smith and Harrison (1962) found a significant increase in performance in the control, motor, and reversed-visual groups in relation to number of hits and trials acquired. The visual and mental practice groups reduced their number of errors, while simultaneously increasing the total number of hits and trials. It was concluded that visual and mental practice techniques are the most beneficial in increasing accuracy on the punchboard test.

Surburg (1968) also conducted a study to test the effectiveness of methods of mental practice (audio,

visual, or audio-visual) in developing the forehand tennis drive. One hundred eighty-three male junior college students were divided into seven different groups. Each subject was tested on the Broer-Miller tennis test at the beginning and the end of experimental study. An adaptation of the Broer-Miller test was used to estimate the subject's skill level on performing the forehand tennis drive.

The following group techniques for mental practice were used:

1. The Audio-mental group - this group listened to the recorded tape portion of the task, without visual affiliation;

2. The Visual-mental group - this group viewed a film of the task, without audio affiliation;

3. The Audio-visual mental group - this group both viewed and listened to a description of the task;

4. The Control group - this group received no practice of any kind.

In addition to the three mental practice groups, there were three correlating groups. However, the subjects in the three correlating groups did not mentally rehearse the skill described in the film or tape which they had previously seen or heard.

The subjects practiced for eight weeks with three practice sessions per week. Data were analyzed by covariance techniques, *t* tests, and Scheffe's test. The best method of training was the audio-mental practice. This group had the widest margin between initial and final scores and higher group means. Audio, visual, and audio-visual instructions used as methods of mental practice were extremely beneficial in improving the forehand drive. Results of this study also indicated that mental practice had to be of a concentrated nature, without interference from external stimuli, to improve motor performance.

Mental Practice and Bowling

Research in bowling with the use of mental practice has been limited. Tufts (1963) found no difference in bowling performance when bowlers used mental or physical practice. In order to determine initial and final scores, the subjects bowled five lines in three nights before and after the experimental period. The experimental period was conducted over a three-week period. The physical practice group bowled one line per night on three nights each week, while the mental practice group met three nights per week to practice mentally for 17 minutes without the assistance of any physical practice.

In related research, Webster (1940) inferred that beginning bowlers usually learn through methods of imitation. For example, the novice can best perform a task when the desired performance is demonstrated by an expert in the field. By viewing the correct procedure, the beginner is better able to recognize when he is doing the skill correctly or incorrectly. This provides a model for students to use as they mentally and physically practice a skill.

Affiliated Bowling Studies

Research studies were reviewed in order to determine information about bowling scores at different skill levels, male and female norms, and plateauing effects in bowling. Three studies were examined.

Bowling norms and learning curves were developed by Phillips and Summers (1950). The subjects included college women from over 22 colleges and universities. Norms were established at each level of ability at the end of ten lines, and for each subsequent five lines bowled. It was found that a decline in the learning curve first appears at the fifth or sixth line and is more noticeable as skill improves.

Martin (1960) conducted a study to establish norms which could assist in evaluating and classifying

college men and women at different skill levels in required physical education classes. The average bowling score was 111.26 for beginning males, 97.31 for beginning females, 134.42 for intermediate males, and 117.11 for intermediate females. The beginning groups had higher improvement scores than the intermediate groups because the learning potential was greater.

Martin and Keogh (1964) developed norms for college men and women in elective physical education classes. Males and females were classified separately into nonexperienced and experienced bowlers. The range for nonexperienced male bowlers was 104 to 183; the range for nonexperienced female bowlers was 77 to 147. The range for experienced bowlers was 100 to 221 for men, and 82 to 172 for women. There was no difference in improvement scores for men and women in each skill classification, however, men bowlers had a 15 to 20 point higher average than women bowlers.

Summary

A review of the literature revealed a limited number of studies which were directly related to mental practice and bowling. Therefore, the resumé of the literature focused upon research studies which compared mental and

physical practice, and identified factors which influence the effectiveness of mental practice. Important information derived from the review were (1) alternative techniques used in mental practice, (2) amount of time which should be devoted to mental practice per session, and (3) national norms for establishing and identifying skill levels in bowling.

CHAPTER III

Procedures

The initial procedures were to investigate and review the literature in the areas of mental and physical practice. Studies were reviewed in order to identify methods of mental practice used specifically to promote skill performances. Information from the review of the literature was utilized in this investigation to assist in identifying treatment conditions and to classify beginner and intermediate bowlers.

A pilot study was conducted during the fall term, 1978, using beginning and intermediate bowlers registered in bowling classes at North Texas State University. The purposes of the pilot study were to (1) evaluate the clarity and method of presentation of types of mental practice to students, (2) assess the experimental setting or environment in relationship to distractions or need for special locations, and (3) determine the time necessary for treatment conditions. In addition, it was important to establish the leveling-off mark in skill for beginners and intermediates and to determine the statistical power (the number of subjects in each group) necessary for each treatment group.

The results of the pilot study provided valuable information which was used in the experiment. Based upon individual game scores and semester accumulative averages, it was determined that consistency in performance was reached after 11 games for both beginner and intermediates. It had been anticipated that the intermediate bowler would reach the leveling-off mark faster than the beginner, however, this supposition was not substantiated. In addition, 10 subjects per treatment group yielded an F power beyond the .01 level. The results of the pilot study also showed that the clarity and method of presentation and the time allocated for treatment conditions were adequate.

Subjects

The subjects for this study were 85 male and female bowlers. Thirty women and fifteen men constituted the beginning bowling group, and twenty women and twenty men constituted the intermediate bowling group. The students were undergraduate males and females enrolled in beginning and intermediate bowling classes at North Texas State University, Denton, Texas, during the spring semester of 1979. Futhermore, the subjects chosen met the established criteria for equality of performance technique which included spot bowling and

use of a four-step approach with a hook delivery. Determination of skill level and classification as a beginner or an intermediate bowler was based upon national norms cited by Martin (1960). Permission for use of the subjects was obtained from the Chairperson of the Division of Physical Education and the Coordinator of the physical education activity program at North Texas State University.

The subjects for this study were randomly assigned from selected subject pools to the treatment groups. The two skill-level groups consisted of nine beginning male and female bowlers and eight intermediate male and female bowlers in each treatment group.

Procedures

All testing was conducted at the Brunswick Holiday Bowling Lanes, Denton, Texas. Students were assigned to lanes one through 15 and were exposed to all lanes prior to the experimental session. In order to record completed game scores, the students used the Peabody Telescope score sheet. The student also needed individual bowling shoes, a bowling ball, and marking pencils. Additional equipment needed for experimentation included stop watches, written handouts, tape recorder, film from the National Bowling Association, and newspapers.

Each treatment group was instructed by the same experimenter or assistant throughout the study in order to minimize variability. In order to avoid an experimenter effect, a training session was conducted prior to the research study so that the assistants understood the concept, procedures, and overall responsibilities necessary to conduct the mental practice sessions. Therefore, all assistants received verbal and written instructions about their duties and responsibilities, and they attended a practice (see Appendices for written instructions).

Scores of lines for students enrolled in the beginning and intermediate bowling classes were collected during the first six weeks of classes. Based upon the results of the pilot study, 11 games were bowled. After consistency in performance was achieved, the scores from three games were collected. These scores were used for the establishment of selected pools of subjects relative to sex and bowling average. Subjects were then randomly assigned by sex and average to a designated treatment group. Each treatment group contained an equal number of males and females to account for differences in bowling performance exhibited by men and women (Martin, 1960; Martin & Keogh, 1964). After

assignment to treatment groups, subjects bowled six games using 12 sets of mental practice. All bowling classes met two days a week for one and one-half hours. During the testing, one game and two sets of mental practice were completed each class day.

Each game contained two sets of five minutes of mental practice (free imagery, directed visual, directed reading, or directed audio) prior to the first frame and the sixth frame in each game. The following treatment conditions were used:

1. Free Imagery.--Subjects were asked to think about and see themselves performing the designated bowling skill. During the free imagery technique, subjects were asked to close their eyes and mentally picture themselves executing the four step approach, hook, and spot bowling. Each subject was asked to complete and rehearse the skill five times during the five minute period;

2. Directed Visual.--Subjects were asked to view a film loop from the National Bowling Association and see themselves performing the designated bowling skills. Each subject was shown the 90-second film twice. After each showing of the loop, the subjects were instructed to close their eyes and perform the mental practice for one minute;

3. Directed Reading (see Appendices for written description).--Subjects were asked to read a detailed written outline of the designated bowling skill. They read the instruction sheet twice. After each reading the subjects had one minute of mental practice in which they closed their eyes and pictured themselves executing the four step approach, hook and spot bowling as described on the handout;

4. Directed Audio.--Subjects were asked to listen to the taped sounds of the designated bowling skills. They listened to the recorded sounds ten successive times over a 90-second period. The first time the instructor asked them to listen and try to picture themselves performing the skills. Before the students heard the tape the second time, they were instructed to listen specifically for the rhythm in the footwork, the release, the ball rolling down the lane, and the initial contact of the ball with the pins. The subjects were then asked to close their eyes for one minute and mentally picture themselves performing the specific skills while trying to duplicate the rhythmic sounds of the tape.

A group using physical practice only was included in the study. The subjects read the newspaper for a five minute period while the treatment groups

practiced the skills mentally. During the reading session, the subjects talked freely, however, they could not talk about bowling.

Mental practice for each group was conducted in the assigned seating area behind lanes. The students rotated lanes within their treatment groups on a prescribed rotation schedule for each treatment group (see Appendices, Table A and B). This rotation was necessary in case a lane change was warranted due to equipment failure. Three adjacent lanes with three bowlers per lane were assigned to each treatment group. The treatment session for mental practice followed a prescribed pattern (see Appendices, Table C), as did the treatment session for the control group (see Appendices, Table D). During mental practice the subjects were not to communicate with one another, however, this was accepted behavior during physical practice.

All students bowled ten recorded frames each class session. Regulation bowling procedures were followed when bowling each frame. Subjects were instructed not to physically or mentally practice their bowling skills outside of class.

Students who were not selected for participation in the study bowled on extra lanes located away from students in the treatment groups. This procedure was

undertaken in order to avoid non-participant interference. Subjects who were absent during the testing period were not tested at a later date but were omitted from the study.

Various changes were incorporated in the study as a direct result of a decrease in sample size. The number of subjects per treatment group, the balance of groups by sex, and the skill level demonstrated by the subjects were altered. Because of large absenteeism among the beginning male sample, the male subjects were deleted from the study for the beginning classification. Therefore, the number of subjects in the beginning bowling group was reduced from an original sample size of 45 to 28 female subjects only. In the intermediate group a reduction in subjects also was necessary because of absenteeism, however, it influenced the design in different ways. In order to statistically equate and shape the treatment groups by size, sex, and skill at the intermediate bowling level, the experimenter randomly selected and deleted either male or female subjects depending upon the necessity. The depreciation of the sample from 40 to 30 subjects restricted any measurement of sex differences because of inadequate representation.

Analysis of Data

The data were analyzed by use of a two-way analysis of variance with repeated measures (Popham, 1967) for both the beginning and the intermediate groups. The ANOVA with repeated measures was used to determine if significant differences existed between (1) treatment groups, (2) treatments, and (3) to identify and locate interaction effects of the treatment means. The independent variables were the treatment conditions and the 12 sets of mental practice. The dependent variables were the bowling scores. Alpha was .05. Data were analyzed by the IBM Model 50 Computer System at the North Texas State University Computer Center.

Summary

This chapter described the design and procedures used in the investigation. It included a discussion of the pilot study, subjects tested, selection and establishment of specified criteria, testing procedures, and a statistical analyses of the test results of the pilot study.

CHAPTER IV

Findings of the Study

The purpose of the present investigation was to determine the influence of four different techniques of mental practice on the physical performance of beginning and intermediate bowlers. Twenty-eight females constituted the beginning groups and 30 male and female bowlers comprised the intermediate groups.

The study incorporated a five-by-twelve factorial design. Thus, a two-way analysis of variance with repeated measures was used in the interpretation of the experimental data. The .05 level of significance was established for this study. The independent variables were the five treatment conditions of free imagery, directed visual, directed reading, directed audio, and a group using physical practice. The dependent variables consisted of the bowling scores of the subjects in each treatment group, thereby identifying the subjects' bowling performances. Treatment sessions included 12 sets of mental practice after each five frames of bowling for six games.

Subjects were exposed to ten weeks of instruction prior to experimentation. Subjects then bowled three

games to ascertain performance scores for assignment to beginner or intermediate classifications (see Appendices, Table E & F).

The means and standard deviations for bowling performance of beginners under the selected conditions of mental practice are depicted in Table 1. Each game consisted of two sets of mental practice after five frames of bowling.

The means for the five beginning groups reflected marginal variation in the groups. The differences in group means or bowling averages prior to experimentation and after experimentation were 4.04 (free imagery), 3.99 (directed visual), -.87 (directed audio), -3.1 (directed reading) and 2.25 (physical practice).

The highest mean scores under the treatment conditions are found during the final four treatments, or games 11 and 12, for the beginning group. The greatest increase in performance for the physical practice group occurred after treatment five or midway through the third game.

A two-way analysis of variance with repeated measures was used to determine differences in performance scores obtained by the female bowlers as a direct result of treatment conditions. The results of this analysis are found in Table 2.

Table 1

Group Means and Standard Deviations for Beginning Bowlers

Treatment Groups	Per 5 Frames: Pre Experimental Means	Per 5 Frames: Group Means	Games 1: Frames 5th 5th 10th 10th M	Games 1: SD	Games 2: Frames 5th 5th 10th 10th M	Games 2: SD	Games 3: Frames 5th 5th 10th 10th M	Games 3: SD
Free Imagery	50.83	54.87	55.67	13.82	58.00	13.13	56.83	13.41	58.50	14.99	53.17	12.30	50.33	7.39
Directed Visual	49.08	53.07	41.40	6.65	50.00	8.72	60.60	16.52	47.60	11.46	47.20	12.64	56.60	11.35
Directed Reading	51.57	48.47	48.50	12.31	47.67	8.98	47.00	12.36	46.50	14.10	43.17	10.32	50.33	14.11
Directed Audio	50.08	49.21	48.17	9.95	45.00	7.40	54.33	11.43	46.50	11.13	54.17	4.35	49.33	18.34
Physical Practice	50.12	52.37	44.33	10.65	56.00	18.76	47.50	11.67	57.50	13.37	59.83	12.48	58.33	13.85

Table 1--Continued

Treatment Groups	Pre Experimental Means (Per 5 Frames)	Group Means (Per 5 Frames)	Games 4 Frames 5th M	Games 4 Frames 5th SD	Games 4 Frames 10th M	Games 4 Frames 10th SD	Games 5 Frames 5th M	Games 5 Frames 5th SD	Games 5 Frames 10th M	Games 5 Frames 10th SD	Games 6 Frames 5th M	Games 6 Frames 5th SD	Games 6 Frames 10th M	Games 6 Frames 10th SD
Free Imagery	50.83	54.87	53.33	12.24	53.17	17.06	61.00	18.35	53.00	11.03	52.50	9.77	53.00	15.84
Directed Visual	49.08	53.07	63.20	20.24	50.60	13.35	51.60	9.76	46.60	8.26	57.00	18.18	64.40	31.69
Directed Reading	51.57	48.47	52.83	11.28	36.17	7.22	51.67	14.21	58.67	16.58	56.00	19.19	43.17	8.84
Directed Audio	50.08	49.21	50.83	10.44	52.67	9.39	42.83	12.12	49.17	17.47	49.67	6.77	47.33	17.62
Physical Practice	50.12	52.37	54.33	14.75	47.83	14.13	56.67	14.42	45.33	10.46	49.17	10.65	51.67	17.62

Table 2

Two-Way Analysis of Variance with Repeated Measures For Beginning Bowlers Using Mental Practice Techniques

	DF	SS	MS	F	p
Between subjects	28				
B (Groups)	4	2006.34	501.58	1.06	0.40
Error B	24	11390.89	474.62		
Within subjects	319				
A (Treatments)	11	1396.19	126.93	0.83	0.61
AB (Interaction)	44	7536.80	171.29	1.12	0.29
Error W	264	40416.81	153.09		

The data for the beginning bowlers clearly illustrate no differences between groups after treatment conditions (Roscoe, 1975). The F ratio for the between subject comparison of groups was not statistically significant, therefore, bowling performance was not different among the groups using free imagery, directed visual, directed reading, directed audio, and physical practice. In addition, the F ratio for the within subject comparison of treatments was not significant, indicating no difference between bowling scores after each set of mental practice.

The interaction comparison of treatments and groups was not statistically significant.

The means and standard deviations for bowling performance under the five practice conditions at the intermediate skill level are presented in Table 3. Both male and female subjects were in each treatment group.

The means for the five intermediate groups represented minimal variation in the groups. The differences in group means or bowling average prior to experimentation and after experimentation were 4.0 (free imagery), 3.41 (directed visual), 1.58 (directed reading), -3.83 (directed audio) and .3 (physical practice).

The intermediate bowlers reached a peak in physical performance at the middle stages of treatment. For three of the four treatment groups, based upon mean scores, the most effective use of mental practice occurred during the fifth and sixth treatment session which involved the fifth game. The group with physical practice had the highest mean score after treatment 10 or game five.

The results of a two-way analysis of variance with repeated measures for intermediate bowlers practicing

Table 3

Group Means and Standard Deviations For Intermediate Bowlers

Treatment Groups	Per 5 Frames: Pre Experimental Means	Per 5 Frames: Group Means	Games 1: Frames 5th M	Games 1: Frames 5th SD	Games 1: Frames 10th M	Games 1: Frames 10th SD	Games 2: Frames 5th M	Games 2: Frames 5th SD	Games 2: Frames 10th M	Games 2: Frames 10th SD	Games 3: Frames 5th M	Games 3: Frames 5th SD	Games 3: Frames 10th M	Games 3: Frames 10th SD
Free Imagery	63.41	67.32	65.00	14.56	68.00	8.63	71.00	26.99	66.20	3.27	71.20	21.63	78.40	24.90
Directed Visual	64.42	67.83	61.17	15.50	70.00	18.57	61.67	11.88	67.83	23.44	75.33	13.50	70.83	14.69
Directed Reading	64.75	66.33	69.83	14.96	73.33	17.76	64.83	10.22	63.17	5.56	68.83	18.96	75.33	8.94
Directed Audio	67.50	63.67	65.00	10.56	68.67	7.03	54.17	11.62	61.33	14.24	56.83	16.80	59.67	14.61
Physical Practice	60.50	60.08	63.67	13.37	58.50	15.03	61.63	5.49	60.50	24.02	52.17	14.59	63.83	3.92

Table 3--Continued

Treatment Groups	Pre Experimental Means	Group Means	Games 4 Per 5 Frames 5th M	5th SD	10th M	10th SD	Games 5 Per 5 Frames 5th M	5th SD	10th M	10th SD	Games 6 Per 5 Frames 5th M	5th SD	10th M	10th SD
Free Imagery	63.41	67.32	77.80	12.75	61.80	15.12	66.20	30.01	57.00	18.27	56.20	10.33	69.00	19.90
Directed Visual	64.42	67.83	65.50	10.95	66.67	9.67	71.33	15.13	68.50	15.37	67.83	20.43	67.33	17.11
Directed Reading	64.75	66.33	65.67	25.34	66.83	15.30	58.50	11.08	70.33	25.12	62.17	13.17	57.17	13.48
Directed Audio	67.50	63.67	56.17	8.28	75.67	6.83	76.67	10.63	63.00	13.31	69.33	11.41	57.50	8.29
Physical Practice	60.50	60.08	55.83	17.10	50.00	22.32	59.83	23.84	73.33	41.47	55.33	11.06	66.16	23.62

under free imagery, directed visual, directed reading, directed audio, and physical conditions are presented in Table 4.

Table 4

Two-Way Analysis of Variance with Repeated Measures for Intermediate Bowlers Using Mental Practice Techniques

	DF	SS	MS	F	p
Between subjects	28				
B (Groups)	4	2846.28	711.57	0.88	0.49
Error B	24	10394.73	808.11		
Within subjects	319				
A (Treatments)	11	1481.30	134.66	0.58	0.84
AB (Interaction)	44	10753.14	244.39	1.05	0.39
Error W	264	61374.93	232.48		

The data reflect no significant differences at the .05 level. Consequently, performances in bowling using four different types of mental practice and one type of physical practice produced minimal differences in skill attainment.

Discussion of the Findings

In the present study 28 female beginning bowlers and 30 male and female intermediate bowlers practiced mentally using either free imagery, directed visual, directed reading, or audio techniques prior to physical performances. In addition, a physical practice group was included in the experiment. Since the majority of the research literature (Clark, 1960; Oxendine, 1968; Singer, 1975; Twining, 1949; Vandell, David, & Clugston, 1943) supports the beneficial effects of mental practice, this investigation was conducted in order to identify and determine the types of mental practice which are most beneficial in increasing the levels of physical performance for beginning and intermediate bowlers.

The current investigation found no significant differences between the four types of mental practice. Although Smith and Harrison (1962) found that visual techniques were more beneficial than other types of mental conditions in increasing accuracy on the punchboard test, and Surburg (1968) cited the techniques of audio, visual, and audio-visual as the most successful in developing the forehand drive in tennis, the advantages of different types of mental practice were not substantiated

in this study. In addition, the enhancement of physical proficiency by mental rehearsal (Singer, 1975) in contrast to physical practice alone was not supported in the present investigation. Treatment groups using mental practice were not different from the physical practice group. The lack of significant findings could be directly attributed to sampling error (Clark & Clark, 1970). It is highly probable that the sampling error of sample size influenced the outcome of this study. Instead of the original 10 subjects per treatment condition, which was determined in the pilot study to be a reliable statistical power, experimental groups were reduced to unequal cell sizes of five-to-six for beginning bowlers and equal cell sizes of six for intermediate bowlers. The sample size of the treatment groups was significantly low enough to prevent observable variance. Subjects were dropped from the study because of absences from the bowling classes which prevented control of the experimental conditions. The lack of attendance by some participants led to the reduction of sample size.

It must be remembered that this investigation sought to identify the effects of mental practice in a realistic, non-contrived bowling situation. The advantages of high external validity based upon reduction

of artificiality and high internal validity based upon control of the variables by an experimenter in a natural setting can be countered by the disadvantages of time, unobstrusive measures, and total control (Martens, 1975). This appears to be the situation in the present study, since voluntary participation led to absenteeism by subjects. Futhermore, the natural environment was a public bowling facility in which careful controls of extraneous noises and spectators were not appropriate. Therefore, the degree of concentration may have been altered.

Finally, the number of treatment sessions involving sets of mental practice could have been too repetitious. Perhaps the monotony of the same pattern led to boredom or a reduction in psychological set for subjects.

This study found no differences in the employment of various types of mental practice nor an increase in physical skills as a direct result of mental imagery in contrast to physical practice alone. There was, however, no decrement in total group performance as a result of the introduction of mental practice. On the contrary, beginners as a whole remained relatively equal in performance with an original group average in bowling of 100.66 compared to a final average after treatment of 100.68.

Similarly, the intermediate group improved its bowling average from 128 to 131. Women bowlers in this group had a minimal increase of 119 to 121, while men had a greater improvement with an increase from 137 to 140.

Summary

A review of the collection of data for beginning and intermediate bowlers under four different conditions of mental practice revealed no significant effects. Because of the results, no techniques could be singled out as the most sufficient in increasing bowling performance.

CHAPTER V

Summary, Conclusions, Recommendations

Purposes and Procedures

The purpose of the study was to determine the influence of free imagery, directed visual, directed reading, and directed auditory techniques as different types of mental practice on the skill performance of beginning and intermediate bowlers. A control group using physical practice was incorporated for comparative effects.

The subjects were forty-five beginning bowlers and forty intermediate bowlers registered in bowling classes at North Texas State University during the spring semester of 1979. Due to the nature of the field experiment and unexpected absenteeism, all beginning male subjects and ten male and female bowlers at the intermediate level were eliminated from the study in order to statistically shape the treatment groups. As a result, 28 beginning female bowlers and 15 male and 15 female intermediate bowlers completed the study.

The experimental period included three phases in which (1) subjects received instruction and bowled

11 games to obtain bowling consistency; (2) a collection of scores on games 12, 13, and 14 for determination of a bowling average, validation of skill level based upon national norms, and assignment to the treatment groups; and (3) subjects bowled six games using 12 sets of prescribed mental practice.

Each game contained two sets of five minutes of mental practice (free imagery, directed visual, directed reading, or directed audio) prior to the first frame and the sixth frame in each game. A physical practice group also had a break from physical activity during these time periods, but they did not employ a mental practice technique.

All students bowled ten recorded frames each class session. Regulation bowling procedures were followed when bowling each frame. The time period for the actual testing was nine hours divided into one and one-half hour segments.

Data were analyzed by use of a two-way analysis of variance with repeated measures to determine significant differences between treatment groups. Alpha was .05.

Findings

The following are the results of the present investigation:

1. No significant differences were found between scores of female bowling groups using four different conditions of mental practice;

2. No significant differences were found between scores of intermediate male and female bowling groups using four different conditions of mental practice;

3. No significant differences in performances of beginning female bowlers existed between groups employing mental practice techniques and physical practice only;

4. No significant differences in performances of intermediate male and female bowlers existed between groups employing mental practice techniques and physical practice only.

Conclusions

The results of this investigation would seem to justify the following conclusions:

1. The bowling performances of beginning female bowlers and intermediate male and female bowlers are similar when using the mental practice techniques of free imagery, directed visual, directed reading, and directed audio;

2. Bowlers who use strategies of mental practice are similar in performance to those who use physical practice.

Recommendations

The following recommendations are offered:

1. A replication of this study should be conducted using a larger sample size;

2. This study should be repeated using beginning male bowlers;

3. A replication of this study should be completed to determine the influence of sex differences and various skill levels;

4. This investigation should be repeated using different age groups to ascertain the importance of imagery at different stages of development;

5. The use of various amounts of time employed for effective mental practice should be investigated.

APPENDICES

Written Instructions for Assistants

All students will practice five minutes of mental practice prior to the first frame and the sixth frame in each game. The assistant is to instruct the student on procedures and time the mental practice sessions. Accuracy is essential. (Table C, Time Schedules).

Mental practice for each group will be conducted in the assigned seating areas behind the lanes. The students will rotate lanes within their treatment groups on a prescribed rotation schedule for each treatment group. (Table A & B).

During mental practice the subjects are not to communicate with one another, however, this is accepted behavior during physical practice.

Instruct the subjects not to physically or mentally practice their bowling skills outside of class. Futhermore, instruct the subjects not to discuss the mental practice techniques among themselves or with other students.

Written Description For Directed Reading Group

In the ready position situate your grip so that the thumb is at 10:00 and the fingers at 4:00 (right hand bowler). During this position the designated target located fifteen feet from the foul line is viewed. Keep your eyes fixed upon your target spot throughout your approach, release, and follow-through.

In executing the approach, as the right foot goes forward the ball is simultaneously pushed out. As the second step is taken with the left foot, the free hand releases from the ball allowing the throwing arm to start the ball in a downward pendulum arc of the backswing. In the third step, step with the right foot straight forward and thus allow the ball to finish its backswing. Finally when the third step is completed, be prepared for your slide and release. This is initiated by gradually bending your knees and at the same time fixing your eyes firmly on the target area. As you start your step, allow the momentum of the ball to carry forward into a smooth downward swing, release, and follow-through over the designated target. Remember throughout the approach to not only gradually bend at the knees, but also at the waist. This method assists in rolling the ball onto the lane and not throwing.

Table A

Intermediate Bowlers: 2:00 Class

Location for Mental Practice and Physical Practice

And Lane Rotation for Experimental Groups

Groups	Lane for Mental Practice	Lane Assignment for Bowling Day #1	Day #2	Day #3	Day #4	Day #5	Day #6
Directed Audio							
a. Four subjects	Lane #1	# 1	# 2	# 1	# 2	# 1	# 2
b. Four subjects	Lane #1	# 2	# 1	# 2	# 1	# 2	# 1
Directed Reading							
a. Four subjects	Lane #3	# 3	# 4	# 3	# 4	# 3	# 4
b. Four subjects	Lane #3	# 4	# 3	# 4	# 3	# 4	# 3
Physical Practice							
a. Four subjects	Lane #5	# 5	# 6	# 5	# 6	# 5	# 6
b. Four subjects	Lane #5	# 6	# 5	# 6	# 5	# 6	# 5
Free Imagery							
a. Four subjects	Lane #7	# 7	# 8	# 7	# 8	# 7	# 8
b. Four subjects	Lane #7	# 8	# 7	# 8	# 7	# 8	# 7
Directed Visual							
a. Four subjects	Lane #9	# 9	#10	# 9	#10	# 9	#10
b. Four subjects	Lane #9	#10	# 9	#10	# 9	#10	# 9

Table B

Beginning Bowlers: 3:30 & 12:30 Classes

Location for Mental Practice and Physical Practice

And Lane Rotation for Experimental Groups

Groups	Lane for Mental Practice	Lane Assignment for Bowling Day #1	Day #2	Day #3	Day #4	Day #5	Day #6
Directed Audio							
a. Three subjects	Lane # 1	# 1	# 2	# 3	# 1	# 2	# 3
b. Three subjects	Lane # 1	# 2	# 3	# 1	# 2	# 3	# 1
c. Three subjects	Lane # 1	# 3	# 1	# 2	# 3	# 1	# 2
Directed Reading							
a. Three subjects	Lane # 4	# 4	# 5	# 6	# 4	# 5	# 6
b. Three subjects	Lane # 4	# 5	# 6	# 4	# 5	# 6	# 4
c. Three subjects	Lane # 4	# 6	# 4	# 5	# 6	# 4	# 5
Physical Practice							
a. Three subjects	Lane # 1	# 1	# 2	# 3	# 1	# 2	# 3
b. Three subjects	Lane # 1	# 2	# 3	# 1	# 2	# 3	# 1
c. Three subjects	Lane # 1	# 3	# 1	# 2	# 3	# 1	# 2
Free Imagery							
a. Three subjects	Lane # 7	# 7	# 8	# 9	# 7	# 8	# 9
b. Three subjects	Lane # 7	# 8	# 9	# 7	# 8	# 9	# 7
c. Three subjects	Lane # 7	# 9	# 7	# 8	# 9	# 7	# 8
Directed Visual							
a. Three subjects	Lane #10	#10	#11	#12	#10	#11	#12
b. Three subjects	Lane #10	#11	#12	#10	#11	#12	#10
c. Three subjects	Lane #10	#12	#10	#11	#12	#10	#11

Table C

Mental Practice Treatment Schedules

Procedures		
Number one	-	five minutes of mental practice
Number two	-	one warm-up throw
Number three	-	five frames of bowling
Number four	-	five minutes of mental practice
Number five	-	five frames of bowling
Number six	-	record scores of games (collected by instructor)

Table D

Schedule for Physical Practice

Procedure		
Number one	-	five minutes of reading a newspaper
Number two	-	one warm-up throw
Number three	-	five frames of bowling
Number four	-	five minutes of reading a newspaper
Number five	-	five frames of bowling
Number six	-	record scores of games (collected by instructor)

Table E

Pre Test Game Average Over Three Games For

Beginning Female College Bowlers

Subject	Games 1			2			3			Averages	
	5th Frames	10th Frames	Total	5th Frames	10th Frames	Total	5th Frames	10th Frames	Total	5th Frame	Game
01	35	43	78	43	58	101	32	35	67	41.00	82
02	42	49	91	48	41	89	54	61	115	49.16	98
03	64	61	125	51	49	100	37	78	115	56.66	113
04	45	50	95	40	73	113	50	74	124	55.33	110
05	38	70	108	51	85	136	32	36	68	52.00	104
06	64	50	114	64	37	101	54	74	128	57.16	113
07	43	44	77	45	44	99	40	41	81	42.83	85
08	43	39	82	59	43	102	37	49	86	45.00	90
09	52	54	106	50	53	103	67	61	128	56.11	113
10	46	47	93	39	40	79	44	50	94	44.33	86
11	49	49	98	24	42	66	50	48	98	43.66	87
12	61	69	130	87	54	141	44	63	107	63.00	112
13	68	68	136	45	60	105	26	58	84	54.11	108
14	55	55	110	71	56	127	53	48	101	56.33	112

Table E--Continued

Subject	Games 1			Games 2			Games 3			Averages	
	Frames 5th	10th	Total	Frames 5th	10th	Total	Frames 5th	10th	Total	5th Frame	Game
15	43	50	93	55	81	136	50	55	105	55.66	111
16	38	18	56	23	45	68	40	56	96	36.66	73
17	43	44	77	75	67	142	49	54	103	55.33	109
18	44	49	93	54	43	97	53	54	107	49.50	99
19	56	39	95	60	35	95	48	63	111	50.16	100
20	41	35	76	33	44	77	46	52	98	41.83	83
21	41	81	122	57	42	99	45	55	99	53.50	107
22	47	42	89	57	58	115	45	52	97	50.16	100
23	46	56	102	58	48	106	65	52	117	54.16	108
24	39	31	70	60	33	93	28	34	62	39.10	78
25	64	36	100	56	37	93	65	63	128	53.50	107
26	32	46	78	63	49	112	58	25	83	45.50	91
27	46	50	96	61	66	127	49	49	98	53.50	107
28	51	74	125	47	69	116	39	50	89	55.00	110

Table F

Pre Test Game Average Over Three Games For Intermediate

Male and Female College Bowlers

	Games										
	1			2			3			Averages	
	Frames										
Subject	5th	10th	Total	5th	10th	Total	5th	10th	Total	5th Frame	Game
F 01	43	67	110	91	54	145	72	61	133	64.83	129
F 02	62	50	112	50	63	113	51	70	121	57.66	115
F 03	70	41	111	50	65	115	51	66	117	57.16	115
M 04	62	67	129	88	63	151	51	71	122	67.00	152
M 05	81	74	155	72	75	147	34	84	118	70.00	146
M 06	54	50	104	66	82	148	49	84	133	64.16	126
F 07	54	76	130	87	40	127	56	41	97	59.00	118
F 08	49	50	99	67	51	118	52	76	128	57.50	115
F 09	76	53	129	65	36	101	84	60	144	62.33	124
M 10	65	48	113	72	69	141	94	71	165	69.83	139
M 11	59	61	120	74	67	141	85	69	154	69.16	138
M 12	85	89	174	92	50	142	58	82	140	68.50	143
F 13	59	51	110	40	38	78	79	80	159	57.83	115
F 14	58	59	117	54	73	127	47	50	97	69.16	114

Table F--Continued

Subjects		Games 1 Frames 5th	1 10th	1 Total	2 5th	2 10th	2 Total	3 5th	3 10th	3 Total	Averages 5th Frame	Game
F	15	39	48	87	64	80	144	62	69	131	60.33	121
M	16	84	89	173	53	106	159	50	67	117	74.83	146
M	17	73	59	132	75	70	145	74	66	140	69.50	139
M	18	64	72	136	73	55	128	55	91	146	68.33	136
F	19	86	59	143	54	50	94	38	53	91	56.66	114
F	20	73	52	125	86	40	126	83	73	155	67.66	135
F	21	78	59	137	63	63	126	39	62	101	60.66	121
M	22	62	97	159	70	64	134	85	76	161	75.66	151
M	23	74	69	143	86	88	174	72	77	149	77.66	155
M	24	63	53	116	81	67	148	73	69	142	67.66	135
F	25	52	72	124	75	86	161	30	76	106	65.16	130
F	26	49	44	93	41	73	114	70	64	134	56.83	114
F	27	51	32	83	51	51	102	54	87	141	54.33	128
M	28	55	56	111	66	43	109	65	55	120	56.66	133
M	29	49	79	128	59	68	127	78	69	147	67.00	134
M	30	72	68	140	60	69	129	53	56	109	63.00	134

Table G

Scores of Beginning Female College Bowlers

Under Specified Mental Practice Conditions

Subject	Experimental Group	Games 1 Frames 5th	1 Frames 10th	1 Total	Games 2 Frames 5th	2 Frames 10th	2 Total	Games 3 Frames 5th	3 Frames 10th	3 Total
01	Free Imagery	47	66	113	43	53	96	54	52	106
02		73	49	122	55	35	90	32	50	82
03		57	42	99	49	66	115	57	49	106
04		66	64	130	58	71	129	68	52	120
05		57	77	134	82	75	157	60	38	98
06	Directed Visual	42	52	94	58	52	110	50	42	92
07		45	36	81	33	47	80	51	50	101
08		37	60	97	74	29	103	30	61	91
09		50	52	102	70	60	130	64	72	136
10		33	50	83	68	50	118	41	58	99
11	Directed Reading	52	43	95	62	39	101	51	52	103
12		71	63	134	41	55	96	50	72	122
13		40	40	80	49	51	100	48	46	94
14		38	53	91	54	36	90	28	28	56
15		49	47	96	50	68	118	50	52	102
16		41	40	81	26	30	56	32	52	84
17	Directed Audio	40	41	81	47	35	82	54	31	85
18		54	35	89	63	53	116	58	49	107
19		55	51	106	53	35	88	59	41	100
20		48	49	97	45	63	108	56	36	92
21		33	40	73	73	51	124	49	62	111
22		59	54	113	45	42	86	49	80	129
23	Physical Practice	51	71	122	41	63	104	72	82	154
24		33	44	77	34	36	70	70	49	117
25		35	38	73	55	71	126	65	48	113
26		38	41	79	40	50	90	55	67	122
27		49	57	106	66	55	121	59	47	106
28		60	85	145	49	70	119	38	57	95

Table G--Continued

Games									Average	
4			5			6				
Frames										
5th	10th	Total	5th	10th	Total	5th	10th	Total	Game	Frame
47	44	91	44	46	90	61	66	127	104	51.92
35	37	72	60	64	124	38	33	71	93	49.75
48	86	134	93	45	138	62	61	123	119	59.58
65	53	118	53	70	123	59	73	132	125	62.67
67	51	118	46	46	92	50	42	92	115	57.58
65	48	113	51	50	101	57	32	89	100	49.92
80	69	149	38	51	89	36	53	89	98	49.08
52	37	89	48	43	91	51	69	120	98	49.25
84	40	124	64	55	119	86	106	196	134	67.25
35	59	94	57	34	91	55	52	107	99	49.33
63	36	99	50	61	111	44	32	76	97	48.75
43	45	88	40	59	99	41	58	99	106	53.16
59	31	90	62	50	112	88	45	133	101	50.75
39	29	68	39	70	109	67	37	104	86	43.17
47	45	92	75	90	155	58	42	100	110	55.25
66	31	97	44	32	76	38	45	83	79	39.75
54	52	106	29	22	51	49	53	102	84	42.25
62	60	122	50	71	121	48	39	87	107	53.50
32	59	91	38	49	87	52	41	93	94	47.08
50	61	111	62	60	122	39	53	92	104	51.83
58	47	105	45	56	101	50	60	110	104	52.00
49	37	86	33	37	70	60	38	98	97	48.50
81	36	117	58	59	117	51	53	104	120	59.83
42	31	73	49	46	95	35	52	87	87	43.42
43	47	90	32	34	66	60	36	96	94	47.00
51	54	105	62	32	94	51	44	95	97	48.75
48	48	96	72	51	123	60	85	145	116	58.08
61	71	132	67	50	117	38	40	78	114	57.17

Table H

Scores of Intermediate College Bowlers Under Specified Mental Practice Conditions

Sex / Subject	Experimental Group	Games 1 Frames 5th	1 10th	1 Total	2 5th	2 10th	2 Total	3 5th	3 10th	3 Total
F 01	Free Imagery	34	50	84	54	51	105	48	61	109
F 02		60	58	118	100	71	171	51	64	115
F 03		78	71	149	54	64	118	64	52	116
M 04		75	60	135	51	65	116	108	117	225
M 05		42	73	115	49	63	112	69	86	155
M 06		70	78	148	101	68	169	64	73	137
F 07	Directed Visual	54	51	115	42	60	102	60	71	131
F 08		51	80	131	62	46	108	78	62	140
F 09		52	43	95	63	63	126	74	54	128
M 10		50	97	147	75	47	122	71	83	154
M 11		72	63	135	56	85	141	100	93	193
M 12		88	76	164	72	106	178	69	62	131
F 13	Directed Reading	79	71	150	54	62	116	64	91	155
F 14		54	51	95	69	55	124	68	70	138
F 15		72	78	150	53	69	112	62	80	142
M 16		59	78	137	69	70	139	52	73	125
M 17		61	95	156	64	62	126	106	66	172
M 18		94	77	171	80	61	141	61	72	133
F 19	Directed Audio	54	61	115	42	75	117	55	47	102
F 20		54	62	116	39	49	88	48	43	91
F 21		70	76	146	52	81	133	62	64	126
M 22		66	74	140	64	64	128	81	63	144
M 23		64	75	139	63	49	112	64	84	148
M 24		82	64	146	65	50	115	31	57	88
F 25	Physical Practice	46	66	112	57	44	101	33	67	100
F 26		77	84	161	59	51	110	45	68	113
F 27		79	60	139	60	39	99	59	61	120
M 28		68	51	119	59	52	111	66	59	125
M 29		60	45	105	72	74	146	69	61	130
M 30		52	45	97	64	103	167	41	67	108

Table H--Continued

Games									Averages	
4			5			6				
Frames										
5th	10th	Total	5th	10th	Total	5th	10th	Total	Game	Frame
58	48	106	70	47	117	45	43	88	101	50.75
59	55	114	60	44	104	50	47	97	120	59.92
72	41	115	37	50	87	71	63	134	120	59.92
85	66	151	95	84	182	63	77	140	158	79.08
81	82	163	39	40	79	50	59	109	122	61.08
92	65	157	100	67	167	47	99	146	154	77.00
52	68	110	75	61	136	55	52	107	117	58.42
51	50	101	95	71	166	78	60	138	131	65.33
71	72	143	50	42	92	37	46	83	111	55.58
71	79	150	61	86	147	65	86	151	145	72.58
73	64	137	74	73	147	96	75	171	154	77.00
75	67	142	73	78	151	76	85	161	154	77.25
74	83	157	61	51	112	56	61	117	134	67.25
38	40	78	54	47	101	57	57	114	108	54.17
49	78	127	42	61	103	74	35	109	124	61.92
61	62	123	55	115	170	41	51	92	131	65.50
61	73	134	64	82	146	73	64	137	145	72.58
111	65	176	75	66	141	72	75	147	151	75.75
52	86	138	69	44	112	84	68	152	123	61.33
56	70	126	79	63	142	52	48	100	110	55.25
42	73	115	74	76	150	70	66	136	134	67.17
61	69	130	72	51	123	77	50	127	132	66.00
61	74	135	97	77	174	61	59	120	138	69.00
65	82	147	69	67	136	72	54	126	126	63.17
53	31	84	23	48	71	56	46	102	95	47.50
64	27	91	61	53	114	60	39	99	115	57.33
72	50	122	63	156	219	45	104	149	141	70.67
30	51	81	57	54	111	61	71	132	113	56.58
73	90	163	98	55	153	70	78	148	141	70.42
43	51	94	57	74	131	40	59	99	116	58.00

References

Clark, V. L. Effect of mental practice on the development of a certain motor skill. Research Quarterly, 1960, 31, 560-569.

Clarke, D. H., & Clarke, H. H. Research processes in physical education, recreation, and health. Englewood Cliffs, N.J.: Prentice-Hall, 1970.

Corbin, C. B. Effects of mental practice on skill development after controlled practice. Research Quarterly, 1967, 38, 536-538.

Cratty, B. J. Psychology and physical activity. Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Fleishman, E. A., & Hempel, W. E. The relation between abilities and improvement with practice in a visual discrimination reaction task. Journal of Experimental Psychologist, 1955, 49, 301-310.

Fleishman, E. A., & Hempel, W. E. Factorial analysis of complex psychomotor performance and related skills. Journal of Applied Psychologist, 1956, 40, 96-104.

Hopkins, K. D., & Glass, G. V. Basic statistics for the behavioral sciences. Englewood Cliffs, N.J.: Prentice-Hall, 1978.

Jones, J. G. Motor learning without demonstration of physical practice, under two conditions of mental practice. Research Quarterly, 1965, 35, 270-276.

Kelsey, I. B. Effects of mental practice and physical practice upon muscular endurance. Research Quarterly, 1961, 32, 47.

Martens, R. Social psychology & physical activity. New York: Harper & Row, 1975.

Martin, J. L. Bowling norms for college men and women. Research Quarterly, 1960, 31, 113-116.

Martin, J. L., & Keogh, J. Bowling norms for college men and women. Research Quarterly, 1964, 35, 325-327.

Moody, D. L. Imagery differences among women of varying levels of experience, interests, and abilities in motor skills. Research Quarterly, 1967, 38, 441-447.

National Bowling Council (LTB plus). Let it happen. Van Nuys, Ca.: Richard NFG, 1973. (Film).

Oxendine, J. B. Psychology of motor learning. Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Oxendine, J. B. Effect of mental and physical practice on the learning of three motor skills. Research Quarterly, 1969, 40, 755-762.

Phillips, M., & Summers, D. Bowling norms for college women. Research Quarterly, 1950, 21, 377-385.

Phipps, S. J., & Morehouse, C. A. Effects of mental practice on the acquisition of motor skills of varied difficulty. Research Quarterly, 1969, 40, 773-778.

Popham, J. W. Educational statistics. New York: Harper & Row, 1967.

Richardson, A. Mental practice: A review and discussion part I. Research Quarterly, 1967, 38, 95-108.

Richardson, A. Mental practice: A review and discussion II. Research Quarterly, 1967, 38, 263-273.

Roscoe, J. T. Fundamental research statistics for the behavioral sciences. (2nd ed.). New York: Holt, Rinehart and Winston, Inc., 1975.

Sage, G. H. Introduction to motor behavior: A neuro-psychological approach. (2nd ed.). Reading, Ma.: Addison-Wesley, 1977.

Singer, R. N., & Witker, J. Mental rehearsal and point of introduction within the context of overt practice. Perceptual and Motor Skills, 1970, 31, 169-170.

Singer, R. N. Motor learning and human performance. New York: Macmillan, 1975.

Schick, J. Effects of mental practice on selected volleyball skills for women. Research Quarterly, 1970, 31, 88-94.

Smith, L. E., & Harrison, J. S. Comparison of the effects of visual, motor, mental and guided practice upon speed and accuracy of performing a simple eye-hand coordination task. Research Quarterly, 1962, 33, 299-307.

Smyth, M. M. The role of mental practice in skill acquisition. Journal of Motor Behavior, 1975, 7, 199-206.

Start, K. B. The relationship between intelligence and the effect of mental practice on the performance of motor skill. Research Quarterly, 1960, 31, 643-649.

Start, K. B. The influence of subjectively assessed "games ability" on gain in motor performance after mental practice. Journal of General Psychology, 1962, 67, 169-173.

Stebbins, R. J. A comparison of the effects of physical and mental practice in learning a motor skill. Research Quarterly, 1968, 39, 714-720.

Surburg, P. R. Audio, visual, and audio-visual instruction with, in developing forehand tennis drive. Research Quarterly, 1968, 39, 728-734.

Tufts, S. A. The effects of mental practice and physical practice on the scores of intermediate bowlers. Unpublished Doctoral Dissertation, University of North Carolina, Greensboro, 1963.

Trussell, E. M. Mental practice as a factor in learning a complex motor task. Unpublished Doctoral Dissertation, University of California, Berkeley, 1958.

Vandell, R. A., Davis, R. A., & Clugston, H. A. The function of mental practice in the acquisition of motor skill, Journal of General Psychology, 1943, 29, 243-250.

Webster, R. W. Psychological factors involved in motor skill performance as exemplified in bowling. Research Quarterly, 1940, 11, 42-50.

Wilson, M. E. The relative effect of mental practice and physical practice in learning the tennis forehand and backhand drives. Unpublished Doctoral Dissertation, State University of Iowa, 1961.

Whiteley, G. The effect of mental rehearsal on the acquisition of motor skill. Unpublished Doctoral Dissertation, University of Manchester, 1962.