# A STUDY OF THE RELATIONSHIP BETWEEN THE ABILITY TO LEARN SELECTED GROSS MOTOR SKILLS IN TENNIS AND THE ABILITY TO CONTROL MUSCULAR TENSION CONSCIOUSLY

A THESIS

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We hereby recommend that the thesis prepared under our supervision by Judith D. Walton entitled "A Study of the Relationship Between the Ability to Learn Selected Gross Motor Skills in Tennis and the Ability to Control Muscular Tension Consciously"

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# CHAPTER I

## ORIENTATION TO THE STUDY

### Introduction

It has been reported that in the United States alone citizens spend in excess of 300 million dollars annually on tranquilizers in order to soothe their "jangled" nerves.[1] One only has to survey the current magazines on a newsstand to find an article dealing with the subject of tension. One of the best-selling books of the past decade was How to Stop Worrying and Start Living.[2] America, perhaps more than any other nation, has become acutely aware of the problems induced by tension, and with this awareness has come a recognition of the need for positive measures of control.

Physical educators agree that their discipline is based upon movement, and efficient movement, in turn, is based upon the development of certain minimal levels of muscular tension. Tense muscles, characterized by nonresiliency or inelasticity, exhibit themselves especially when one is in motion.[3]

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[1] Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics, (Dubuque, Iowa: Wm. C. Brown Company, 1966), p. 251.

[2] Dale Carnegie, How to Stop Worrying and Start Living, (New York: Simon & Schuster, Inc., 1948).

[3] Josephine L. Rathbone, Teach Yourself to Relax, (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1967), p. 27.

Broer[1] states that a smooth sequence of muscular action is necessary for coordinated movement to occur and unnecessary tension interferes with this sequence. Research tends to indicate that there are optimal levels of tension development needed in order to perform a task efficiently, and that muscular tension either below or in excess of this level would tend to inhibit the performance of the task.[2]

Cratty[3] notes that numerous investigations have been undertaken to attempt to determine the relationship between tension and motor performance. In general, the findings reported by Cratty tend to demonstrate that performance of the less complex tasks is facilitated by induced tension whereas the performance of more complex tasks is inhibited. Since the learning and performance of most activities in the physical education curriculum involves complex movements, it would seem logical that physical educators would become interested in the relationship between tension and motor learning and motor performance.

The question should be raised, can physical educators, whose very livelihood is based upon the teaching of complex motor skills, do anything to alleviate tension and perhaps facilitate learning and performance in their students? In

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[1] Marion R. Broer, Efficiency of Human Movement, (Philadelphia and London: W. B. Saunders Company, 1966), p. 375.

[2] M. Gladys Scott, Analysis of Human Motion, (New York: F. S. Crofts & Company, 1942).

[3] Bryant J. Cratty, Movement Behavior and Motor Learning, (Philadelphia: Lea & Febiger, 1967), p. 179.

light of recent research findings, the answer to this question would seem to be a tentative "yes".[1] The key to releasing tension appears to be the ability to voluntarily relax one's muscles. That this can be accomplished has been demonstrated.

In 1938, Jacobson[2] reported on a method for teaching relaxation which has been widely acclaimed and utilized in succeeding studies of relaxation. He hypothesized that the individual is capable of learning to recognize and control minute amounts of muscular tension within his body. In separate applications of Jacobson's techniques, Benson[3] and Paben[4] reported that subjects undergoing training in relaxation were able to learn and perform gross motor skills significantly faster than were subjects who experienced no instruction in relaxation techniques. Jacobson[5] and Lovett,[6] in separate

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[1] Marjorie Paben, "A Study of the Effect that the Control of Muscular Tension Has on the Learning of a Novel Gross Motor Skill," (unpublished M. A. thesis, the Texas Woman's University, Denton, 1968).

[2] Edmund Jacobson, Progressive Relaxation, (Chicago: The University of Chicago Press, 1938).

[3] David Benson, "Effects of Concomitant Learning in Relaxation and Swimming on Swimming Improvement," (unpublished study, University of California, Los Angeles, 1968), cited in Cratty, Movement and Motor Learning, p. 183.

[4] Paben, "Effect of Tension on Learning".

[5] Edmund Jacobson, "The Course of Relaxation in Muscles of Athletes," American Journal of Psychology, XLVIII (1936), 98-108.

[6] Dorothy Jo Lovett, "Kinesthetic Perception of Muscular Tension as Measured by Electromyography in Low and High Skilled Women," (unpublished Ph. D. dissertation, the Texas Woman's University, Denton, 1968).

studies involving highly skilled and poorly skilled subjects, found that the more highly skilled subjects were more readily able to recognize muscular tension and control it than were the more poorly skilled subjects.

Previous studies present some interesting implications for the physical education profession. Two hypotheses can be proposed: (1) that a program in relaxation and tension control contributes to the efficient learning and performance of gross motor skills, and (2) that those persons who already are able to control muscular tension efficiently will be those who are able to learn and perform gross motor skills more efficiently than those not able to control muscular tension. There is a lack of sufficient research to either support or refute these hypotheses. The present investigation has been designed to add to the knowledge available in this area. Much of the previous reported research utilized as subjects highly skilled and poorly skilled performers, athletes versus non-athletes. The present study was concerned with subjects who were relatively unskilled and were untrained in relaxation techniques.

It is the investigator's hope that this research will be a significant contribution to knowledge in the area of motor learning and tension control. According to deVries,[1] physical educators have pursued knowledge for developing more strength, more endurance and more power in muscle tissue, but

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[1] deVries, Physiology of Exercise, p. 253.

the future will demand in our curricula more emphasis upon how to relax muscles as well as how to tense them.

## Statement of the Problem

The proposed investigation entailed the comparison of the ability to learn selected gross motor skills involved in playing tennis and the successful utilization of these skills in competition with the ability to control consciously the muscular tension of the upper extremity. The investigation specifically involved the forearm flexors under controlled conditions. The subjects were eighteen university women enrolled in a beginning tennis course in the required program of physical education at the Texas Woman's University, Denton, Texas, during the spring semester of the 1968-1969 academic year. Subjects were equated with respect to previous experience in tennis and other racket sports and with respect to initial ability in selected skills involved in playing tennis. Upon the basis of the findings, a conclusion was drawn with respect to whether the subjects who were able to learn the selected gross motor skills in tennis most efficiently were more readily able to control muscular tension than were their less efficient counterparts.

## Definitions and Explanations of Terms

For the purpose of clarification, the following definitions and explanations of terms have been established for use in this investigation:

A. Relaxation: Relaxation means to loosen or limber the muscular system so that there is no measureable tenseness or strain. The degree of relaxation achieved by the subjects was measured by means of quantitative electromyographic techniques.

B. Tension: "Tension. . . is overt muscular contraction caused by an emotional state or increased effort."[1]

C. Electromyograph: The electromyograph has been described as:

> . . . an instrument which measures and records muscle action potentials. It is basically an amplifier which receives current conducted from electrodes.[2]

D. Gross Motor Skills: Gross motor skills may be defined as:

> . . . patterns of body movement involving complex motor coordination which achieve desired results with minimum expenditure of physical energy . . . gross motor skills refer to those related to large muscle activity.[3]

E. Learning: Learning was defined as:

> . . . the rather permanent change in behavior brought about through practice . . . motor learning may be termed as a stable

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[1]Cratty, Movement and Motor Learning, p. 161.

[2]Gerald G. Hershberg and Arthur S. Abramson, "Clinical Electromyography: Physiologic Basis, Instrumentation, Diagnostic Value," Archives of Physical Medicine, XXXI (September, 1950), 576-78.

[3]Clifford Lee Brownell and E. Patricia Hagman, Physical Education--Foundations and Principles, (New York: McGraw-Hill Book Company, 1951), p. 365.

> change in the level of skill as the result of repeated trials.
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> . . . . . . . . . . . . . . . . . . . . .
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> Learning is a long-range change, demonstrable in retention measures collected over a period of time. . .[1]

F. Efficient Motor Learning: Efficient motor learning was considered to be success in selected tennis objective skill tests or successful performance in tennis singles competition.

<u>Purposes of the Study</u>

The general purpose of the investigation was to determine the relationship between the ability to efficiently learn selected gross motor skills in tennis and the ability to relax consciously the muscular tension in the muscles of the upper extremity. Specifically, the investigator proposed to test the following hypotheses:

A. There is no significant relationship between the ability to efficiently learn selected gross motor skills in tennis as measured by objective skills tests and the ability to relax consciously the muscular tension of selected forearm flexors.

B. There is no significant relationship between the ability to successfully compete in tennis singles and the ability to relax consciously the muscular tension of selected forearm flexors.

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[1] Cratty, <u>Movement and Motor Learning</u>, p. 245.

C. There is no significant relationship between the ability to efficiently learn selected gross motor skills in tennis as measured by objective skills tests and the ability to successfully compete in tennis singles.

## Delimitations of the Study

The proposed study was subject to the following delimitations:

A. One group of selected subjects which was comprised of those students enrolled in a beginning tennis class in the required program of physical education at the Texas Woman's University, Denton, Texas, during the spring semester of the 1968-1969 academic year.

B. Selection of the instruments designed to measure the efficiency of motor learning in the selected gross motor skills in tennis.

C. Determination of leagues for conducting round robin singles competition by means of the selected instruments.

D. Measurement of relative success in tennis for the total group by means of selected intra-league and inter-league play rather than a complete round robin tournament.

E. Measurement of the degree of muscular tension during participation in the muscular tension control program by means of quantitative electromyography.

F. Selection of the level of control of muscular tension to be achieved by the subjects. This will be determined by pretesting of randomly selected subjects utilizing the electromyograph. Since in the course of his work Jacobson discovered that it takes a period of approximately six weeks to approximate total relaxation,[1] the level required of the subjects in this investigation was less than total relaxation.

<u>Summary</u>

Recent research findings tend to indicate that a program in conscious muscular tension control facilitates the learning of gross motor skills. This is a relatively new field of research endeavor, however, and more research is needed to determine the relationship between the learning of gross motor skills and the ability to recognize and consciously relax muscular tension. The presence of excessive amounts of tension tends to inhibit the performance of gross motor skills. The purpose of the present investigation was to study the relationship between the ability to efficiently learn selected gross motor skills in tennis and the ability to consciously control muscular tension.

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[1] Jacobson, <u>Progressive Relaxation</u>.

Chapter I presented information relative to muscular tension control and its potential role in the learning of gross motor skills. The chapter also included definitions and explanations of terms used in the study, purposes of the study, and delimitations of the study.

In Chapter II a description of previous research reports which were found to be pertinent to the investigation will be presented.

# CHAPTER II

## RELATED LITERATURE

### Introduction

Ever since the pioneer work of Jacobson in the 1930's, the concept of tension control and its relationship to learning has been studied by éducators. The physical educator, more so than others, has become increasingly aware of the implications for including programs of tension control in the curriculum. By its very nature, physical education is concerned with efficient human movement and this concern in its totality should also include nonmovement.[1] Cary[2] indicates that participants in athletics, which may be expanded to include all physical performances, should be taught how to use only those muscles needed to perform a given movement. Cratty states that:

> . . . the close relationship between levels of muscular tension and motor performance involving simple and complex movements is obvious. However, the exact manner in which tension affects performance and learning is not always as is expected.[3]

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[1] A. Bruce Frederick, "Tension Control in the Physical Education Classroom," Journal of Health, Physical Education, and Recreation, XXXVIII (September, 1967), 42.

[2] Helen A. Cary, "Relaxation for Effective Living," The Journal of School Health, XX (October, 1950), 220.

[3] Cratty, Movement and Motor Learning, p. 175.

Cratty further suggests that in order to promote efficient movement, one must thoroughly grasp the principles of tension and tension control, or relaxation.[1]

A number of studies have been reported which have attempted to determine a relationship between tension and motor performance and learning. The studies presented in this chapter are closely related to the present investigation.

## Studies in Relaxation and Tension

Cary[2] has indicated that relaxation in relation to activity means operating at maximum efficiency with minimum effort, and that tension beyond the needed amount results in lost motion and awkward, inaccurate motions. Ryan[3] tested subjects on a motor learning task involving balancing on the pivotal platform of a stabilometer. Ryan noted that increased tension impaired the performance of balancing on the stabilometer, and that the rate of learning was independent of the state of tension.

Duffy[3] investigated the relationship between the quality of performance and tension of selected skeletal muscles.

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[1] Ibid., p. 183

[2] Cary, "Relaxation for Living," p. 220.

[3] E. Dean Ryan, "Effects of Stress on Motor Performance and Learning," Research Quarterly, XXIII (March, 1962), 111-119.

[4] Elizabeth Duffy, "The Relation Between Muscular Tension and Quality of Performance," American Journal of Psychology, XLIV (July, 1932), 535-46.

Graphic records were obtained of the pressure upon dynamographs held in each hand during discriminative reactions to three kinds of pictures and during a tapping performance. The results of the investigation revealed high degrees of muscular tension to be generally associated with performance of a poor quality. Duffy suggested that high tension may be a greater liability for children than for adults since the latter are supposed to have a more highly developed ability to inhibit and to coordinate reactions.

Gregg[1] investigated the changes in generalized tension that accompany performance of psychomotor tasks. Upon the basis of the findings, Gregg concluded that increases in general tension, as related to the steadiness task of his study, appeared to accompany a decrement in performance and a decrease in tension appeared to accompany an improvement in relation to the tapping task of the study.

Stauffacher[2] studied the effect of varying degrees of induced muscular tension upon the rate of learning. While supporting weights suspended by pulleys, subjects were to memorize nonsense syllables and reproduce them by spelling. The subjects were tested under four conditions of muscular

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[1]Lee W. Gregg, "Changes in Distribution of Muscular Tension During Psychomotor Performance," _Journal of Experimental Psychology_, LVI (July, 1958), 70-77.

[2]James C. Stauffacher, "The Effect of Induced Muscular Tension Upon Various Phases of the Learning Process," _Journal of Experimental Psychology_, XXI (1937), 26-46.

tension: (1) no tension in terms of weight held, (2) one-fourth maximum tension, (3) one-half maximum tension, and (4) three-fourths maximum tension. Stauffacher indicated that the findings were not significant, but a certain amount of muscle tonus enhances the learning process. The increases in learning occurred when the amount of induced tension was near one-half of the subjects' maximal point. Greater or lesser amounts of tension seemed to have little effect on the learning rate.

A study undertaken by Castaneda and Lipsitt[1] indicated that stress, which may be considered the same as tension as defined in this investigation, facilitated performance with respect to the learning of simple light-switch combinations. This task involved two horizontally parallel rows of eight lights and eight switches. The subject had to learn which switch activated each light and memorize these combinations.

In a simple motor task involving grasping a suspended tennis ball, reversing directions to touch a key, and then grasping a second ball, Howell[2] concluded that those subjects given an electric shock to produce tension and motivation performed significantly faster than did those subjects with no such stimulus.

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[1]Alfred Castaneda and Lewis Lipsitt, "Relation of Stress and Differential Position Habits to Performance in Motor Learning," Journal of Experimental Psychology, LVII (January, 1959), 25-29.

[2]M. L. Howell, "Influence of Emotional Tension on Speed of Reaction and Movement," Research Quarterly, XXIV (March, 1953), 22-32.

Lazaras, Deese and Osler,[1] however, found that stress and anxiety in learning tended to impair both verbal and perceptual-motor performances. Courts[2] and Freeman[3] indicated that in studies involving finger oscillation, mirror-drawing, intensity limen for touch, eyelid reflex, and mental arithmetic, the more complex the performance or skill, the earlier tension will have inhibitory effects.

A study conducted by Lakie,[4] involving galvanic skin response and its relation to task difficulty, showed extremely high and extremely low tension to be associated with poor performance of a task, with a medium degree of tension most facilitory. Russell[5] concluded that a condition of tension below that normally involved in performing the task was superior to either normal tension or excess tension with respect to accuracy of hitting a designated target with a thrown ball.

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[1] R. S. Lazaras, J. Deese and S. F. Osler, "Anxiety and Stress in Learning the Roll of Interserial Duplication," Journal of Experimental Psychology, XLVII (February, 1954), 111-114.

[2] Frederick A. Courts, "Relations Between Muscular Tension and Performance," Psychological Bulletin, XXXIX (1942), 347-67.

[3] G. L. Freeman, "The Optimal Muscle Tensions for Various Performances," American Journal of Psychology, LI (January, 1938), 146-50.

[4] William L. Lakie, "Relationship of Galvanic Skin Response to Task Difficulty, Personality Traits and Motivation," Research Quarterly, (March, 1967), 58-63.

[5] James T. Russell, "Relative Efficiency of Relaxation and Tension in Performing an Act of Skill," Journal of General Psychology, VI (April, 1932) 330-43.

M. L. Jacobson[1] investigated periodic variability of tension in college women, utilizing the electromyograph to measure the degree of tension. She hypothesized that a high tension group of subjects would vary in tension to a greater extent than would a group of subjects classified as low in tension. After studying muscles of the neck, shoulder, elbow, hip, and knee, she concluded that the high tension group did vary in tension significantly more so than did the low tension group.

Haverland[2] undertook a study to determine whether training in relaxation techniques or conditioning exercises can bring about improvement in certain aspects of motor performance. The aspects considered were coordination, steadiness and reaction time. The results indicated that there was no significant difference between the means of changes in performance on four of the five tests administered. Upon the basis of her findings, Haverland concluded that training in Jacobson's techniques of relaxation may result in improved performance in certain aspects of motor skills involving smooth, coordinated and precise movements.

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[1]Marianne L. Jacobson, "An Electromyographic Study of Tension Variability," (unpublished M. S. thesis, University of California, 1962).

[2]Lillian Haverland, "The Effects of Relaxation Training on Certain Aspects of Motor Skill," (unpublished Ph. D. dissertation, University of Illinois, 1953).

E. Jacobson[1] undertook a study to determine the relationship between the ability of athletes to relax as compared to the ability of other students both trained and untrained in relaxation techniques. Records of success at relaxation were obtained through use of an amplifier-galvonometer assembly. Jacobson concluded that, considered as a group, the athletes succeeded in relaxing a particular muscle group to a fuller and more sustained extent than did subjects untrained in relaxation. The athletes' success was inferior to those subjects trained in relaxation techniques.

Evans[2] investigated the influence of relaxation techniques upon the level of tension in college women prior to and following physical education classes. She concluded that most college students can be taught to recognize fatigue due to hypertensions and to utilize methods of reducing its effects. Lyons and Lufkin[3] sought to determine whether ten lessons in relaxation, spaced over a five week period, would significantly lower the muscular tension of college women. They measured twenty-eight muscle groups by means of the electromyograph during the ten fifty-minute sessions. The

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[1] Edmund Jacobson, "The Course of Relaxation in Athletes," American Journal of Psychology, XLVIII (1936), 98-108.

[2] Lura E. Evans., "The Influence of Relaxation Techniques on Varying Levels of Tension in College Women," (unpublished Ph. D. dissertation, State University of Iowa, 1954).

[3] Marjory D. Lyons and Bernadine Lufkin, "Evaluation of Tension Control Courses for College Women," Research Quarterly, XXXVIII (December, 1967), 663-70.

increased ability to relax was measurable, but not to a significant degree.

Paben[1], in an investigation which inspired the present study, sought to determine the effect that the control of muscular tension has upon the learning of a novel gross motor skill. Thirty college women were randomly assigned to one of two groups, designated as experimental and control. The experimental group was given a program of muscular tension control according to the techniques developed by Jacobson and both groups were then taught a novel gross motor skill. Paben concluded that the program of muscular tension control aided in the learning of a novel gross motor skill.

## Studies in Electromyography

Since its development in the middle part of this century, researchers have made extensive use of the electromyograph for testing muscle action potential in various areas of the body. Because of its generally recognized techniques, the electromyograph was chosen as the instrument to measure the amount of tension present in a muscle for the present investigation.

Electromyography operates on the principle that when an impulse reaches the myroneural junction a wave of contraction spreads progressively over the fiber, resulting in a brief twitch.[2] During the twitch a minute electrical potential is

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[1] Paben, "Effect of Tension on Learning."

[2] J. V. Basmajian, Muscles Alive, (Baltimore: The Williams and Wilkins Company, 1962), p. 12.

generated. Since the motor units of a muscle contract at varying instances, the electrical potential is prolonged. Therefore, the electrical result of the various motor unit twitches is a discharge lasting several seconds with a total amplitude measured in microvolts.[1]

Bigland and Lippold[2] investigated the relationship between tension and motor unit activity in a muscle contracting voluntarily. In order to reduce the number of active fibers in the muscle, the ulnar nerve was blocked and the muscle was then stimulated with an Attree stimulator. The tension of the muscle was measured with a strain gauge. Needle electrodes were used to record the potentials of a single motor unit while surface electrodes measured the potentials over the belly of the muscle. The results indicated that tension produced by a muscle contracting voluntarily is proportional to the electrical activity of that muscle.

Slaughter[3] conducted a study to observe the contractions of biarticular muscles involved in prescribed movements of the arms. Surface electrodes were utilized and electromyograms were recorded for the right side of each subject in

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[1] Ibid., p. 13.

[2] Brenda Bigland and O. C. J. Lippold, "Motor Unit Activity in the Voluntary Contraction of Human Muscle," Journal of Physiology, CXXV (1954), 322-25.

[3] Duane A. Slaughter, "Electromyographic Studies of Arm Movements," Research Quarterly, XXX (October, 1959), 326-37.

various movements. To eliminate excessive tenseness in the muscles during execution of the movements, the subjects were instructed to perform the movements in a slow, relaxed manner. Upon the basis of the findings, Slaughter drew conclusions concerning the muscles involved in various prescribed movements of the arm and the extent of their involvement.

Slater-Hammel[1] utilized electromyography to study the contraction-movement relationships in executing the forehand drive in tennis. Through an extensive examination of five skilled subjects, he concluded that the biceps brachii, pectoralis major, anterior deltoid and triceps brachii were the primary contributors in the movement.

Slater-Hammel[2] further utilized the electromyograph to measure kinesthetic perception of muscle force through muscle action potential changes. The performance task consisted of contracting the triceps brachii sufficiently to produce muscle action potentials of approximately 125 microvolts on the voltmeter of the electromyograph. Following the practice trials the subjects attempted to reproduce the same muscular tension with no tactual stimulation. Upon the basis of the findings, Slater-Hammel concluded that the measurement

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[1] Arthur T. Slater-Hammel, "A Study of Contraction-Movement Relationships in the Tennis Stroke," Research Quarterly, XX (March, 1949), 424-31.

[2] Arthur T. Slater-Hammel, "Measurement of Kinesthetic Perception of Muscular Force with Muscle Potential Changes," Research Quarterly, XXVIII (1957), 153-59.

of muscle action potentials appeared to offer definite promise as a test for kinesthetic perception of muscular force.

Lovett[1] determined the relationship between ability in selected gross motor skills and kinesthetic perception of muscular tension as measured by electromyography. A highly skilled group in the gross motor skills of gymnastics or volleyball and a poorly skilled group in these activities were compared in their ability to reproduce selected levels of muscular tension as measured by the electromyograph. The results revealed that the highly skilled subjects were significantly more successful in duplicating the muscular tension than were the poorly skilled subjects.

## Summary

Research in the area of muscular tension and relaxation and its relationship to motor learning and performance has been carried on by various investigators who have arrived at somewhat contradictory conclusions. In general, however, the research tends to indicate that the more complex motor tasks are inhibited by excessive tension whereas the learning and performance of simple tasks is enhanced by the presence of tension. Much continued research is needed in this area.

The electromyograph as a method of measuring tension through the measurement of muscle action potential is a relatively new development. Many experts believe that it offers

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[1] Lovett, "Perception of Muscular Tension."

excellent potential as a method of measurement in this field and its use is becoming widely adopted for the study of tension and relaxation.

Chapter II has presented a review of literature pertinent to this investigation. Chapter III will describe the procedures followed in the development of the present study.

# CHAPTER III

## PROCEDURES OF THE STUDY

### Introduction

The present investigation sought to determine the relationship between the ability to efficiently learn selected gross motor skills in tennis and the ability to consciously relax the muscular tension in selected muscles of the upper extremity. Selected skills tests were utilized to measure efficient learning of selected gross motor skills in tennis, and quantitative electromyography was utilized to determine the amount of muscular tension present in the selected muscle.

The study entailed the use of one group of eighteen college women enrolled in the investigator's beginning tennis class at the Texas Woman's University during the spring semester of the 1968-1969 academic year. All subjects were administered skills tests at the beginning and at the end of the semester as well as participating in a round-robin-type singles tournament. Each subject was subsequently tested to ascertain the ability to consciously relax muscular tension of a specific muscle group.

### Preliminary Procedures

Information was surveyed, studied and assimilated from available documentary sources of data pertinent to all phases of the study, with special emphasis upon tension control, electromyography and learning-success. Many differing opinions concerning the relationship between tension and learning and between learning and success were reported. It was decided to confine this investigation to studying specific muscle groups involved in the execution of selected motor skills in tennis.

## Instrumentation

The electromyographic equipment utilized in this investigation consisted of an Integrating Bioelectric Monitor, electronic counter, Oscilloscope and Biopotential Skin Electrodes. The Integrating Bioelectric Monitor is a voltage-measuring instrument with switchable gains and band width which make it adaptable to all alternate current bioelectric phenomena. The monitor has the ability to amplify and integrate data over precise time intervals, by means of voltage-to-frequency conversion with a digital readout provided in an accessory counter. The electromyographic monitor included a built-in ohm meter, calibration signal, and an audio output to feed back the level of muscle activity of the subject if so desired.

The following monitor settings were used in this study: High Pass cycles per second 10 thousand, Low Pass cycles per second 1.0, and Full Scale .1. The high pass and low pass refer to the frequency control band widths which indicate the frequency range that the monitor will pick up. The full scale setting indicates the amplitude sensitivity. An audio output was utilized in this study as an additional modality to aid the subjects in relaxing. The E & H Instrument Company produced the Biopotential Skin Electrodes which were employed in the testing of each subject.

In order to calibrate the monitor, both a Low Frequency Function Generator and an Audio-Frequency Microvolter were employed. The calibration was accomplished by introducing a controlled output signal from the generator and the Audio-Frequency Microvolter into the monitor and measuring the frequency recorded. The EMG monitor was calibrated each session prior to the testing and at intervals between the testing of subjects. A general purpose oscilloscope, connected to the monitor, graphically depicted the muscular activity and was utilized to check any artifacts which might occur. The electronic counter displayed the digital readout of muscular activity on a four-place column.

## Selection of the Muscle Group

The muscle group tested was selected upon the basis of its functioning in the performance of the selected gross motor skills in tennis. According to kinesiological[1] and electromyographical[2] analysis, the biceps brachii was selected as it was consistently involved in the actions considered in this study.

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[1]Scott, Analysis of Human Motion, pp. 263-70.

[2]Arthur T. Slater-Hammel, "An Action Current Study of the Tennis Stroke," pp. 424-31.

## Selection of the Subjects

The subjects for this investigation were eighteen college women enrolled in the investigator's beginning tennis class at the Texas Woman's University during the spring semester of the 1968-1969 academic year. All potential subjects were interviewed at registration and only those without previous experience in tennis, table tennis, badminton or any other racket sports were allowed to enroll in the class. Subjects were also screened with respect to previous participation in a tension control program and those who had such an experience were excluded from the class. On the first day of class activity, the Revised Dyer Backboard Test of Tennis Ability[1] was administered to the subjects for the purpose of determining the homogeneity of the group. Visual inspection of the data revealed the group to be homogeneous with respect to initial ability in tennis.

## Learning the Selected Gross Motor Skills in Tennis

All subjects were instructed by the investigator in a beginning tennis class which met twice per week for a period of 90 minutes. Each subject received the same instruction, subject to individual teaching in class and the subject's absences from class. The basic skills taught to the class were the forehand and backhand drives and the service. The class was instructed not to practice outside of class time except as out-of-class matches were assigned in an attempt

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[1] Joanna T. Dyer, "Revision of the Backboard Test of Tennis Ability," Research Quarterly, IX (March, 1938), 25-31.

to equalize practice time for all subjects. Verbal questioning of the subjects indicated that no out-of-class practice occurred.

As soon as the skills had been learned, the subjects were administered selected skills tests of tennis ability. These tests were: (1) the Revised Dyer Backboard Test of Tennis Ability[1], (2) the Miller-Broer Test for Forehand and Backhand Drives[2], and (3) the Cobane Test for the Service[3]. A complete description of these tests will be found in the Appendices. These tests were selected upon the basis of their widespread current usage among teachers of tennis, ease of administration and statistical significance. They were administered during two successive class periods by the investigator and a trained assistant who recorded the scores on a prepared score card. The individual scores for each test were converted to T scores and were combined to yield a composite score which was utilized for further analysis.

Tournament Play

After the skills tests had been administered, the subjects participated in an intra-league and inter-league

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[1]Dyer, "Revision of Backboard Test."

[2]Marion Broer and Donna Mae Miller, "Achievement Tests for Beginning and Intermediate Tennis," Research Quarterly, XXI (October, 1950), 303-313.

[3]Edith Cobane, "Test for the Service," DGWS Tennis-Badminton Guide, 1962-64, pp. 46-47.

singles tournament. Subjects were randomly assigned to one of three groups and Bartlett's Test for Homogeneity of Variance[1] was utilized to determine the homogeneity of the three groups upon the basis of the skills tests. The homogeneity of the variance demonstrated that the three groups were equated with respect to ability of the subjects. Table I, illustrating the homogeneity will be found in Chapter IV, page 33.

The tournament was conducted in such a manner that every subject played one set, which constituted the entire match, against every member of her group and played at least one member of each of the other two groups. This meant that the minimum number of matches played by each subject was seven. Subjects played in class and were assigned additional specific matches to be played outside of class. The entire tournament lasted for three weeks. Success in tournament play in tennis was determined by computing the percentage of total number of games won by each subject.

Muscular Tension Control Program

At the conclusion of the singles tournament, the subjects were tested in the Human Performance Laboratory of the College of Health, Physical Education and Recreation in order to determine their degree of muscular tension control as measured by quantitative electromyography. First, the

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[1] Philip H. DuBois, An Introduction to Psychological Statistics, (New York: Harper and Row Publishers, 1965), p. 275.

equipment was shown to the subject, and its operation was explained. The subject was then prepared for the application of the electrodes.

Prior to the application, the skin area over the muscle to be tested was cleansed with alcohol and abraded with sand paper. The adhesive collars were applied to the electrodes which were then filled with electrolyte solution. The electrodes were placed over the muscle in accordance with the procedure suggested by Davis[1], and the ground electrode was placed on the non-dominant arm near the wrist bones.

The electrical resistance of the skin, or impedance of the subject, was tested and the value for a one-second period was recorded. Impedance had to be less than 5,000 ohms in order for the testing to continue. Greater impedance produced interfering artifacts. During the measurement, the oscilloscope was checked for artifacts; and if any occurred, the cause was determined and corrected. If an acceptable level of impedance was not reached, the electrodes were removed, and the subject's skin was again abraded.

The subject was then instructed to enter a grounded copper screen cage and lie on her back, both arms at her sides, on a wooden table. While she was lying there, her initial resting count was recorded by taking three one-second readings and calculating the mean. The resting count

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[1] John F. Davis, Manual of Surface Electromyography, A manual prepared by the United States Air Force, Wright-Patterson Air Force Base, Ohio, (December, 1959).

was an initial recording of the muscle action potential of each subject. The subject was then instructed to listen to directions, which were recorded on a tape recorder, and follow them carefully. These directions will be found in the Appendices.

The directions consisted of having the subject bend her arm at the elbow and tense the biceps muscle three times, starting and stopping on a given signal each time. The tenseness of the muscle was noted each time, and during the rest intervals between trials, the subject was requested to relax the muscle and eliminate all tenseness. The contraction was held for ten seconds during each trial. Prior to the second tensing, the audio output was turned on and left on for the duration of the period. At the conclusion of the third contraction the subject was instructed to lie there for the remainder of the period, striving to relax the muscle completely, thus achieving total silence on the machine. The tape recorder was turned off, and no further directions were given until ten minutes had elapsed. The subject was then informed of her lowest level of achievement and exhorted to relax even more. The total recording time for each subject was 28.83 minutes. One-second readings taken at four-second intervals were recorded continuously on a score sheet for the duration of the test period. Each subject had a total of 336 scores recorded. The raw scores for each subject tested are presented in the Appendices.

## Analysis of the Data

The data collected through the above procedures were submitted to the Pearson Product-Moment Method of Correlation three different times. This was done to determine the relationship between (1) the ability to efficiently learn selected gross motor skills in tennis as measured by selected skills tests and the ability to relax muscular tension consciously, (2) the ability to succeed in tennis as measured by games won in a round robin-type singles tournament and the ability to relax muscular tension consciously, and (3) the ability to efficiently learn gross motor skills in tennis as measured by objective skills tests and the ability to succeed in tennis as measured by games won in a round robin-type singles tournament.

## Summary

Eighteen college women, unskilled in the racket sports, were taught selected gross motor skills in tennis and then tested to determine (1) their ability to learn these skills, (2) their ability to succeed in utilizing these skills to play tennis, and (3) their ability to relax muscular tension. The learning was measured by selected skills tests of tennis ability, the success was measured by an intra-league and inter-league singles tournament. Muscular control was measured by quantitative electromyographic techniques. The test data were treated with the Pearson Product-Moment Method of Correlation in three different combinations.

Chapter IV presents the results of the analysis of the data.

## CHAPTER IV

## RESULTS AND ANALYSIS OF THE DATA

### Introduction

The results and analysis of the data collected are presented in this chapter of the thesis. The interpretation of the data is presented in relation to the three hypotheses that guided the development of this investigation: (1) there is no significant relationship between the ability to learn efficiently selected gross motor skills in tennis as measured by objective skills tests and the ability to relax consciously the muscular tension of selected forearm flexors, (2) there is no significant relationship between the ability to compete successfully in tennis singles and the ability to relax consciously the muscular tension of selected forearm flexors, and (3) there is no significant relationship between the ability to learn efficiently selected gross motor skills in tennis as measured by objective skills tests and the ability to compete successfully in tennis singles. All data were calculated by an Olivetti Underwood Programma 101 calculating computer.

### Analysis of Group Homogeneity

The Revised Dyer Backboard Test of Tennis Ability was administered to the subjects during the first class period.

The range and Standard deviation were computed and the values found were: range equaled 15 and the standard deviation equaled 4.22. Visual inspection of the data revealed the group to be homogeneous with respect to initial ability in tennis.

The subjects were randomly assigned to one of three groups for participation in the singles tournament. These groups were then tested to determine whether they were homogeneous with respect to performance on the objective skills tests. The Bartlett Test for Homogeneity of Variance was utilized to test for homogeneity of the groups. The subjects' scores on the three skills tests were converted to T scores and these scores were combined to yield a total score. These scores were then totaled for each group and were subjected to the test for homogeneity. The obtained results indicated that the three groups were homogeneous with respect to skill in tennis as measured by objective skills tests. The data is presented in Table 1, below.

TABLE 1

PERFORMANCE ON OBJECTIVE SKILL TESTS WITH RESPECT TO BARTLETT'S TEST FOR HOMOGENEITY OF VARIANCE

| Group | Total Score | $x^2$ | df | P* |
|---|---|---|---|---|
| 1 | 936 | | | |
| 2 | 879 | 1.37 | 2 | n. s. |
| 3 | 896 | | | |

*$x^2$ value required for significance with 2 df: .05 level = 5.99

## Analysis of the Data

Data of the subjects' ability to learn selected gross motor skills in tennis as measured by objective skills tests, of the subjects' ability to succeed in a singles tournament, and of the subjects' ability to consciously relax muscular tension of the biceps muscle as measured by quantitative electromyographic techniques were collected. The scores for efficient skill learning were obtained by converting the scores on three separate skills tests to T scores and combining these scores to obtain a total score. The subjects' ability to succeed in a tournament was obtained by finding the percentage of total games won in seven matches of tournament play. The subjects' ability to relax a muscle was measured as the length of time required for the subject to achieve a reading of .010 microvolts or below on the electromyograph and hold this level constant for a period of one minute. These data are presented in the appendix, pages 52-70.

The data were then subjected to a Pearson Product-Moment Correlation performed by the Olivetti Underwood Programma 101 calculating computer. Three correlations were performed each of which will be considered and discussed separately.

The first hypothesis stated that there would be no significant relationship between the ability to learn selected gross motor skills in tennis as measured by objective skills tests and the ability to consciously relax muscular tension. The result of this correlation is presented in Table 2.

TABLE II

COEFFICIENT OF CORRELATION BETWEEN THE ABILITY TO EFFICIENTLY LEARN SELECTED SKILLS IN TENNIS AND THE ABILITY TO CONSCIOUSLY RELAX MUSCULAR TENSION

| Measure | Mean | SD | r | P* |
|---|---|---|---|---|
| Skill Learning | 150.61 | 13.27 | .06 | n. s. |
| Muscular Control | 428.78 | 528.88 | | |

*r value required for significance with 17 df:
.05 level = .46

The results presented indicate that there was no significant relationship between the two variables. This would tend to help substantiate the findings of Paben.[1] Since there is no difference in the ability to control muscular tension between relatively fast and slow learners, it would appear that a program in muscular tension control would be of benefit to enhance the learning of gross motor skills.

The subjects' failure to achieve total muscle silence may be attributed to several different causes. The sensitiity of the electrodes and machine used may have caused a pick-up of activity extraneous to that of the muscle involved in this investigation. The electrodes were placed in accordiance with the directions of Davis, and should have measured only the muscle involved, but in several of the subjects it

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[1] Paben, "Effects of Tension on Learning."

was noted that the audio-output was oscillating with the heart beat of the subject. These subjects, however, achieved a level of relaxation as low as subjects where this phenomena was not noted. Other artifacts may be attributed to disturbances outside of the room in which the subjects were tested.

Although seemingly not total, the subjects' relaxation was such that when a bell indicating the end and beginning of class periods rang it caused no increased activity in the subjects. Other disturbances, which occurred during several test periods did not cause increased excitation of the subjects.

The second hypothesis stated that there would be no significant relationship between the ability to successfully compete in tennis singles and the ability to relax consciously the muscular tension of selected forearm flexors. The results of this correlation are presented in Table 3.

TABLE III

COEFFICIENT OF CORRELATION BETWEEN THE ABILITY TO CONSCIOUSLY CONTROL MUSCULAR TENSION AND THE ABILITY TO SUCCEED IN A TENNIS TOURNAMENT

| Measure | Mean | SD | r | P* |
|---|---|---|---|---|
| Muscular Control | 428.78 | 528.88 | .14 | n. s. |
| Tournament Success | .50 | .18 | | |

*r value required for significance with 17 df:
.05 level = .46

The results presented indicate that there was no significant relationship between these two variables. Those persons who were more successful in competition were not better able to control muscular tension than were less successful competitors.

The third hypothesis of this investigation stated that there would be no significant relationship between the ability to efficiently learn selected gross motor skills in tennis as measured by objective skills tests and the ability to succeed in a tennis singles tournament. The results of this correlation is presented in Table 4.

TABLE IV

COEFFICIENT OF CORRELATION BETWEEN THE ABILITY TO EFFICIENTLY LEARN SELECTED SKILLS IN TENNIS AND THE ABILITY TO SUCCEED IN A TENNIS SINGLES TOURNAMENT

| Measure | Mean | SD | r | P* |
|---|---|---|---|---|
| Skill Learning | 150.61 | 13.27 | .76 | .01 |
| Tournament Success | .50 | .18 | | |

*r value required for significance with 17 df:
.05 level = .46
.01 level = .58

The results presented indicate that success was significantly influenced by skill in tennis. The relationship was quite high, although not as high as might be expected if skill is the only ingredient necessary for success in tennis.

Many top tennis players agree that more than skill is necessary to succeed in tennis. Don Budge, who is one of the few men to win four major singles championships in one year, states that:

> Lawn tennis is . . . a game not only of the hand and foot, but, just as much of the head and heart. The mental faculties are brought into play equally with the physical attributes, and a game of championship quality is evolved only through the proper functioning of both.[1]

Factors other than skill appear to be an influence on success in tennis, but what these factors are and what effect they have has yet to be demonstrated by research. Thorpe[2] found no correlation between intelligence and success, but, as did the present study, found a significant relationship between skill and success.

<u>Summary</u>

The data of the present investigation were collected with respect to the subjects' ability to (1) efficiently learn selected gross motor skills in tennis as measured by objective skills tests, (2) succeed in utilizing these skills in a singles tournament, and (3) consciously relax muscular tension as measured by quantitative electromyography.

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[1]J. Donald Budge, <u>Budge of Tennis</u>, (New York: Prentice-Hall, Inc., 1939), p. 121.

[2]Jo Anne Lee Thorpe, "A Study of Intelligence and Skill in Relation to the Success Achieved by College Women Engaged in Badminton and Tennis Singles Competition," (unpublished Ph. D. dissertation, the Texas Woman's University, Denton, 1964).

The results were treated with the Pearson Product-Moment Method of Correlation to determine the relationship between the variables. The coefficients of .06 between efficient skill learning and muscular control and of .14 between tournament success and muscular control did not reach significance at the acceptable level. The coefficient of .76 between efficient skill learning and tournament success was signigicant at the .01 level.

Chapter V will present a summary of the entire study. The findings will be presented and a conclusion drawn with respect to the results of the analysis of the data. Implications of the findings and recommendations for future studies will also be presented.

CHAPTER V

# SUMMARY, CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS FOR FUTURE STUDIES

## Summary of the Investigation

America has become acutely aware of the problems induced by tension and the need for positive measures of control. Physical education is based upon movement and efficient movement is based upon the development of certain minimal levels of muscular tension. A smooth sequence of muscular action is necessary for coordinated movement to occur and unnecessary tension interferes with this sequence.

Cratty[1] notes that numerous investigation have been undertaken to attempt to determine the relationship between tension and motor performance. In general, the findings tend to demonstrate that performance of the less complex tasks is facilitated by induced tension whereas the performance of more complex tasks is inhibited.

Previous research studies present some interesting implications for the physical education profession. Two hypotheses can be proposed: (1) that a program of relaxation and muscular tension control contributes to the efficient learning and performance of gross motor skills, and

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[1] Cratty, Movement and Motor Learning, p. 179.

(2) that those persons who already are able to control muscular tension efficiently will be those who are able to learn and perform gross motor skills more efficiently than those not able to control muscular tension. The present investigation has been designed to add to the research available in the latter hypothesis. Much of the previous research has utilized as subjects highly skilled and poorly skilled, athletes versus non-athletes. The present research studied subjects who were relatively unskilled and were untrained in relaxation techniques.

The research design involved one group of eighteen college women. These subjects were taught selected gross motor skills in tennis and their learning of these skills was tested by means of objective skills tests. The subjects then participated in a round robin-type tennis singles tournament and their success was measured by computing the percentage of games won in seven tournament matches. The subjects were then tested in the Human Performance Laboratory of the College of Health, Physical Education and Recreation on their ability to relax the tension of a selected muscle by means of quantitative electromyography. The results of each measure were correlated with one another. Upon the basis of the statistical analysis of the findings, a conclusion was drawn with respect to the hypotheses which guided the development of the study.

## Findings of the Study

Three hypotheses guided the development of this investigation. The first hypothesis stated that there is no significant relationship between the ability to efficiently learn selected gross motor skills in tennis as measured by objective skills tests and the ability to relax consciously the muscular tension of selected forearm flexors. Upon the basis of a correlation coefficient of .06, this hypothesis was accepted.

The second hypothesis stated that there is no significant relationship between the ability to compete successfully in tennis singles and the ability to relax consciously the muscular tension of selected forearm flexors. Upon the basis of a correlation coefficient of .14, this hypothesis was accepted.

The third hypothesis which guided the development of this investigation stated that there is no significant relationship between the ability to learn efficiently selected gross motor skills in tennis as measured by objective skills tests and the ability to compete successfully in tennis singles. Upon the basis of a correlation coefficient of .76, this hypothesis was rejected.

## Conclusion of the Study

As a result of the statistical findings of this investigation, it was concluded that the more efficient learners were not able to relax muscular tension to a higher degree than were their less efficient counterparts. It was also concluded that skill had a definite influence on success in singles competition.

## Limitations of the Study

The present study was subject to the following limitations:

A. The impossibility of controlling the subjects' absences from class. Their absences did make a difference in the instruction which they received, although only one subject was absent an excessive number of times.

B. The difference in individual teaching help during the class period. Because of the different errors, different kinds of help were given to individual subjects. An attempt was made to utilize group instruction more than usual, but this did not eliminate individual assistance.

C. The impossibility of testing all subjects for muscular control during the same week. Because of mechanical difficulties with the electrodes, four of the subjects had to be tested the succeeding week, which was the beginning of final examinations. This may have made a difference in the ability to relax muscular tension. In two subjects who were retested during this week, there was no appreciable difference in their ability to relax, indicating that this may have had no bearing on the results of this study.

## Implication for Physical Education

The present investigation has shown that there is no significant relationship between the subjects' ability to learn skills in tennis and succeed in singles competition and their ability to control muscular tension. Paben[1] has demonstrated that a program in relaxation and muscular tension control aids in the learning of a novel gross motor skill. Since physical educators are concerned with teaching motor learning in the most effective manner, it would appear that this field should be explored further. Programs in relaxation and muscular tension control may suggest new horizons for efficient motor learning.

## Recommendations for Further Studies

The following suggestions are recommended for future investigation:

A. The effect of training in relaxation and muscular tension control upon the learning of a specific sports skill such as the service in tennis.

B. The relationship between the academic success of a student and success at relaxation.

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[1] Paben, "Effect of Tension on Learning".

C. The effect of training in relaxation and muscular tension control upon the academic success of a student.

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# APPENDIX A

Plates 1-18: Row Data for Each
Individual Subject for the
Relaxation Phase of the Study

Subjoct 1

IR .011

Imp. 27

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 320 | 2456 | 273 | 2969 | 36 | 10 | 9 | 9 | 10 | 9 | 10 | 9 | 10 | 10 |
| 10 | 9 | 9 | 10 | 10 | 10 | 1674 | 2607 | 3126 | 10 | 10 | 1933 | 119 | 11 |
| 9 | 9 | 9 | 9 | 588 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 10 |
| 9 | 9 | 9 | 9 | 10 | 2025 | 2577 | 2273 | 2216 | 3035 | 3025 | 2743 | 2905 | 2336 |
| 126 | 206 | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 9 | 10 | 9 | 10 | 9 |
| 10 | 9 | 9 | 10 | 10 | 10 | 9 | 9 | 10 | 10 | 9 | 9 | 8 | 9 |
| 9 | 9 | 9 | 9 | 10 | 10 | 9 | 9 | 9 | 10 | 10 | 9 | 9 | 9 |
| 10 | 10 | 9 | 10 | 9 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 9 | 9 |
| 9 | 10 | 9 | 9 | 9 | 10 | 9 | 10 | 9 | 10 | 10 | 9 | 9 | 9 |
| 9 | 9 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 10 | 11 | 9 | 10 |
| 10 | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 9 | 9 | 9 | 10 | 10 | 9 |
| 9 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 10 | 9 | 10 | 9 | 9 | 10 |
| 9 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 |
| 10 | 10 | 9 | 9 | 10 | 10 | 9 | 10 | 9 | 10 | 10 | 9 | 11 | 9 |
| 9 | 10 | 9 | 9 | 9 | 9 | 9 | 10 | 11 | 9 | 10 | 9 | 9 | 9 |
| 9 | 9 | 9 | 9 | 10 | 9 | 10 | 9 | 9 | 9 | 10 | 10 | 9 | 9 |
| 10 | 9 | 10 | 10 | 9 | 9 | 10 | 9 | 9 | 9 | 9 | 10 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 | 8 | 10 | 9 | 10 |
| 9 | 10 | 9 | 10 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 10 | 9 | 10 |
| 10 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 | 8 | 10 | 10 | 8 |
| 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 10 |
| 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 9 |
| 10 | 10 | 9 | 9 | 9 | 11 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 10 | 9 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 10 | 9 |

Plate 1

Subject 2

IR .010

Imp. 9

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 348 | 2130 | 1732 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 11 | 10 |
| 11 | 10 | 11 | 10 | 11 | 10 | 12 | 10 | 10 | 877 | 1942 | 1163 | 19 | 10 |
| 11 | 11 | 10 | 11 | 10 | 10 | 11 | 11 | 11 | 10 | 11 | 11 | 11 | 11 |
| 11 | 11 | 10 | 10 | 10 | 11 | 10 | 12 | 10 | 11 | 11 | 11 | 2734 | 2320 |
| 2427 | 2774 | 2436 | 2331 | 2370 | 2399 | 2265 | 2473 | 2653 | 17 | 2348 | 2278 | 2316 | 11 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 11 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 11 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 11 | 11 | 10 | 10 | 11 |
| 10 | 14 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 14 | 10 | 11 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 11 | 10 | 10 |
| 10 | 10 | 17 | 9 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 9 | 9 |
| 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 9 | 10 | 9 |
| 9 | 10 | 10 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 10 | 9 | 10 | 10 |
| 9 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 10 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 |
| 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 9 | 10 |
| 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 1791 | 2923 | 11 | 10 | 9 | 9 |
| 10 | 9 | 172 | 10 | 20 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 |
| 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 10 | 9 | 9 | 9 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 |
| 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 10 |

Plate 2

Subject 3

IR.012

Imp. 8

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2326 | 1639 | 861 | 1291 | 20 | 11 | 11 | 14 | 11 | 11 | 12 | 11 | 12 | 13 |
| 11 | 11 | 13 | 11 | 13 | 16 | 29 | 16 | 12 | 1542 | 2075 | 821 | 2985 | 13 |
| 33 | 12 | 12 | 12 | 12 | 11 | 13 | 12 | 11 | 11 | 11 | 12 | 13 | 12 |
| 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 2642 | 2923 |
| 2878 | 494 | 198 | 11 | 11 | 11 | 12 | 11 | 13 | 12 | 11 | 10 | 11 | 11 |
| 10 | 11 | 11 | 13 | 11 | 12 | 12 | 12 | 11 | 11 | 11 | 12 | 11 | 11 |
| 11 | 11 | 10 | 11 | 12 | 13 | 12 | 11 | 11 | 11 | 11 | 11 | 10 | 11 |
| 12 | 11 | 10 | 11 | 11 | 11 | 11 | 11 | 12 | 11 | 11 | 11 | 12 | 11 |
| 11 | 10 | 11 | 11 | 12 | 13 | 11 | 11 | 11 | 12 | 11 | 12 | 10 | 12 |
| 11 | 11 | 11 | 12 | 11 | 11 | 11 | 11 | 10 | 11 | 11 | 12 | 11 | 11 |
| 11 | 11 | 11 | 11 | 11 | 12 | 14 | 11 | 12 | 12 | 12 | 11 | 11 | 12 |
| 12 | 10 | 11 | 11 | 11 | 10 | 11 | 11 | 12 | 11 | 11 | 11 | 11 | 11 |
| 11 | 10 | 11 | 10 | 11 | 11 | 10 | 11 | 11 | 11 | 12 | 10 | 11 | 12 |
| 11 | 11 | 12 | 11 | 12 | 11 | 11 | 10 | 11 | 12 | 12 | 12 | 12 | 11 |
| 10 | 11 | 11 | 12 | 11 | 11 | 11 | 10 | 11 | 12 | 10 | 11 | 10 | 11 |
| 12 | 11 | 10 | 12 | 12 | 12 | 11 | 13 | 11 | 11 | 10 | 11 | 11 | 11 |
| 11 | 10 | 10 | 11 | 11 | 10 | 10 | 12 | 10 | 12 | 11 | 11 | 13 | 12 |
| 11 | 11 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 12 | 13 | 12 | 11 | 11 |
| 12 | 11 | 11 | 11 | 10 | 11 | 10 | 11 | 11 | 11 | 10 | 14 | 10 | 10 |
| 11 | 10 | 10 | 10 | 12 | 10 | 12 | 11 | 12 | 11 | 12 | 10 | 10 | 11 |
| 10 | 11 | 11 | 11 | 26 | 11 | 11 | 11 | 11 | 10 | 11 | 11 | 11 | 11 |
| 10 | 11 | 12 | 12 | 10 | 15 | 11 | 10 | 10 | 10 | 11 | 12 | 11 | 10 |
| 11 | 11 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 11 |
| 10 | 11 | 11 | 11 | 12 | 10 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 10 |

Plate 3

Subject 4.

IR .009

Imp. 27

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 917 | 503 | 289 | 15 | 23 | 9 | 9 | 12 | 28 | 40 | 42 | 32 | 8 | 9 |
| 712 | 18 | 10 | 10 | 9 | 10 | 9 | 9 | 9 | 759 | 569 | 211 | 16 | 35 |
| 9 | 8 | 9 | 9 | 440 | 12 | 18 | 13 | 16 | 13 | 12 | 10 | 12 | 11 |
| 11 | 12 | 14 | 11 | 12 | 13 | 10 | 9 | 8 | 10 | 9 | 709 | 534 | 482 |
| 135 | 12 | 141 | 19 | 12 | 9 | 9 | 9 | 9 | 12 | 9 | 8 | 8 | 8 |
| 8 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 8 | 8 |
| 10 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 9 | 8 | 9 | 9 | 8 | 9 |
| 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 8 | 116 | 8 | 8 | 9 | 9 | 9 | 9 |
| 9 | 9 | 9 | 8 | 8 | 11 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 9 |
| 9 | 10 | 9 | 9 | 229 | 9 | 9 | 9 | 8 | 9 | 10 | 17 | 8 | 8 |
| 9 | 8 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 8 |
| 9 | 9 | 8 | 8 | 9 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 10 | 8 |
| 9 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 |
| 9 | 54 | 8 | 8 | 8 | 8 | 9 | 8 | 10 | 8 | 9 | 8 | 9 | 9 |
| 8 | 10 | 9 | 9 | 9 | 8 | 8 | 9 | 9 | 8 | 9 | 8 | 8 | 9 |
| 20 | 8 | 8 | 8 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 9 | 9 | 8 |
| 8 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 8 | 9 | 9 | 8 | 9 | 8 |
| 12 | 8 | 9 | 8 | 8 | 9 | 9 | 8 | 8 | 8 | 9 | 8 | 9 | 8 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 11 | 104 | 8 | 9 |
| 8 | 8 | 8 | 9 | 12 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 8 | 9 |
| 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 10 |
| 9 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 8 | 9 |
| 8 | 9 | 8 | 9 | 8 | 8 | 9 | 33 | 8 | 42 | 8 | 9 | 8 | 10 |

Plate 4.

Subject 5

IR .009

Imp. 7

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1820 | 2838 | 1072 | 9 | 11 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 8 |
| 8 | 9 | 9 | 8 | 9 | 10 | 628 | 8 | 9 | 2098 | 2815 | 67 | 14 | 10 |
| 9 | 9 | 9 | 9 | 9 | 10 | 9 | 8 | 9 | 9 | 9 | 8 | 8 | 8 |
| 8 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 8 | 8 | 9 | 2906 | 2921 |
| 2801 | 391 | 28 | 17 | 10 | 11 | 11 | 11 | 13 | 10 | 10 | 12 | 11 | 11 |
| 11 | 11 | 11 | 9 | 10 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 8 |
| 8 | 9 | 9 | 9 | 8 | 9 | 10 | 8 | 8 | 9 | 9 | 9 | 8 | 8 |
| 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 10 |
| 9 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 |
| 9 | 8 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 8 | 8 |
| 9 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 9 | 9 | 9 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 10 | 9 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 10 |
| 10 | 10 | 8 | 9 | 9 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 8 |
| 9 | 8 | 9 | 10 | 8 | 8 | 8 | 8 | 9 | 9 | 8 | 8 | 9 | 9 |
| 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 9 |
| 8 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 12 | 9 | 8 |
| 9 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 9 | 8 |
| 8 | 8 | 9 | 9 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 8 |
| 9 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 9 |
| 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 9 | 8 |
| 8 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 9 | 8 |
| 10 | 10 | 8 | 9 | 9 | 9 | 9 | 10 | 8 | 8 | 9 | 9 | 9 | 8 |
| 9 | 8 | 8 | 8 | 9 | 8 | 10 | 8 | 8 | 8 | 9 | 10 | 9 | 9 |

Plate 5

Subject 6

IR .008

Imp. 9

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1722 | 2335 | 366 | 19 | 9 | 8 | 9 | 7 | 8 | 8 | 20 | 8 | 8 | 7 |
| 8 | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 1579 | 2548 | 8 | 8 | 8 | 7 |
| 8 | 670 | 17 | 8 | 13 | 175 | 365 | 8 | 7 | 7 | 7 | 8 | 7 | 7 |
| 109 | 7 | 11 | 8 | 8 | 11 | 12 | 17 | 826 | 2142 | 1584 | 152 | 335 | 1471 |
| 10 | 28 | 68 | 9 | 8 | 8 | 8 | 9 | 1070 | 8 | 7 | 2721 | 7 | 7 |
| 8 | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7 | 8 |
| 8 | 7 | 8 | 7 | 8 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 |
| 8 | 8 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 7 | 8 | 7 |
| 8 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 8 | 7 | 7 | 7 | 7 |
| 7 | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 |
| 9 | 8 | 7 | 45 | 8 | 7 | 8 | 8 | 7 | 8 | 8 | 8 | 7 | 7 |
| 7 | 8 | 8 | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 7 | 7 |
| 7 | 8 | 8 | 8 | 7 | 8 | 8 | 7 | 8 | 7 | 8 | 7 | 10 | 8 |
| 7 | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 7 | 7 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 8 | 7 |
| 8 | 8 | 8 | 8 | 7 | 7 | 8 | 8 | 8 | 8 | 7 | 7 | 8 | 7 |
| 8 | 8 | 11 | 8 | 8 | 8 | 8 | 19 | 8 | 9 | 8 | 9 | 8 | 7 |
| 8 | 8 | 8 | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 7 |
| 8 | 8 | 8 | 8 | 7 | 7 | 8 | 8 | 7 | 7 | 7 | 8 | 8 | 8 |
| 7 | 8 | 8 | 7 | 8 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 7 | 8 |
| 7 | 8 | 8 | 7 | 6 | 7 | 8 | 7 | 7 | 7 | 8 | 7 | 8 | 7 |
| 7 | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 8 | 8 | 7 | 7 | 7 | 7 |
| 8 | 7 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7 | 7 |

Plate 6

Subject 7

IR .009

Imp. 15

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 350 | 2859 | 1873 | 99 | 27 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 |
| 8 | 8 | 9 | 8 | 9 | 9 | 8 | 8 | 8 | 2811 | 2883 | 9 | 11 | 25 |
| 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 8 | 8 | 8 | 9 | 8 | 8 |
| 8 | 9 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 2748 | 2677 | 2512 |
| 11 | 9 | 8 | 9 | 9 | 10 | 9 | 8 | 9 | 8 | 8 | 10 | 8 | 8 |
| 8 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 11 |
| 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 |
| 9 | 9 | 15 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 8 |
| 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 9 |
| 8 | 9 | 8 | 9 | 9 | 8 | 9 | 10 | 9 | 8 | 8 | 8 | 8 | 9 |
| 9 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 9 | 20 | 8 | 9 | 8 | 9 | 8 | 8 | 9 | 9 | 8 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 8 |
| 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 |
| 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 |
| 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 8 |
| 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 |
| 8 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 9 |
| 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 17 | 9 |

Plate 7

Subject 8

IR .008

Imp. 15

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 119 | 104 | 26 | 22 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 8 |
| 10 | 9 | 9 | 10 | 9 | 9 | 10 | 9 | 18 | 104 | 62 | 13 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 | 8 | 10 | 9 | 8 | 9 |
| 9 | 10 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 360 | 100 | 78 |
| 87 | 8 | 11 | 10 | 9 | 9 | 10 | 10 | 13 | 8 | 9 | 9 | 9 | 10 |
| 8 | 9 | 9 | 8 | 9 | 10 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 |
| 9 | 10 | 8 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 |
| 8 | 8 | 9 | 8 | 10 | 8 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 |
| 9 | 9 | 9 | 9 | 8 | 10 | 8 | 9 | 9 | 9 | 8 | 9 | 9 | 9 |
| 8 | 9 | 9 | 8 | 9 | 9 | 8 | 10 | 9 | 9 | 9 | 9 | 10 | 9 |
| 9 | 8 | 8 | 9 | 10 | 69 | 9 | 9 | 19 | 9 | 10 | 9 | 10 | 9 |
| 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 8 | 9 | 11 | 9 |
| 9 | 9 | 9 | 10 | 9 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 |
| 96 | 13 | 9 | 9 | 9 | 9 | 8 | 11 | 9 | 8 | 9 | 9 | 8 | 9 |
| 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 | 10 | 8 | 8 | 10 | 8 |
| 9 | 9 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 8 | 10 | 9 | 8 |
| 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 10 | 10 | 10 |
| 9 | 8 | 24 | 9 | 9 | 8 | 9 | 9 | 15 | 8 | 9 | 9 | 8 | 8 |
| 9 | 10 | 9 | 9 | 9 | 9 | 10 | 8 | 8 | 9 | 8 | 8 | 8 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 9 |
| 9 | 9 | 9 | 8 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 9 |
| 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 9 |
| 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 9 | 8 |

Plate 8

Subject 9

IR .009

Imp. 28

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2860 | 2799 | 261 | 14 | 19 | 9 | 8 | 9 | 9 | 9 | 197 | 65 | 54 | 42 |
| 11 | 31 | 9 | 9 | 8 | 8 | 10 | 9 | 2837 | 2796 | 233 | 58 | 9 | 10 |
| 9 | 8 | 9 | 8 | 9 | 8 | 9 | 8 | 9 | 8 | 9 | 9 | 8 | 9 |
| 8 | 8 | 9 | 9 | 8 | 8 | 9 | 8 | 9 | 11 | 2825 | 2752 | 2758 | 188 |
| 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 8 | 9 |
| 8 | 9 | 9 | 8 | 8 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 8 |
| 9 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 10 | 9 | 9 | 9 | 8 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 |
| 9 | 8 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 |
| 8 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 9 |
| 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 9 |
| 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 9 | 8 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 9 |
| 8 | 8 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 |
| 9 | 9 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 8 |
| 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 8 |
| 9 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 8 | 8 | 9 | 9 | 9 |
| 9 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 |
| 9 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 8 | 9 | 9 |
| 8 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 9 | 9 | 8 | 14 | 11 |
| 8 | 9 | 8 | 9 | 8 | 9 | 10 | 8 | 8 | 9 | 8 | 8 | 8 | 8 |
| 9 | 9 | 9 | 8 | 8 | 9 | 11 | 8 | 9 | 8 | 9 | 8 | 8 | 9 |
| 8 | 9 | 9 | 8 | 8 | 9 | 29 | 8 | 9 | 9 | 9 | 9 | 11 | 15 |
| 8 | 8 | 9 | 8 | 8 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 |

Plate 9

Subject 10

IR .009

Imp. 40

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2624 | 2739 | 497 | 33 | 9 | 8 | 10 | 8 | 8 | 9 | 9 | 14 | 14 | 14 |
| 8 | 9 | 10 | 9 | 19 | 20 | 24 | 24 | 2506 | 2778 | 243 | 9 | 9 | 9 |
| 10 | 9 | 9 | 8 | 9 | 1972 | 720 | 249 | 11 | 13 | 16 | 17 | 12 | 10 |
| 11 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 601 | 2928 | 2470 | 3105 | 894 |
| 51 | 211 | 211 | 43 | 147 | 8 | 9 | 9 | 8 | 8 | 1678 | 21 | 9 | 10 |
| 9 | 9 | 9 | 9 | 15 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 |
| 8 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 592 | 68 |
| 19 | 18 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 9 | 9 | 8 | 9 | 9 |
| 9 | 9 | 8 | 9 | 9 | 8 | 9 | 8 | 9 | 9 | 8 | 11 | 16 | 9 |
| 8 | 8 | 8 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 9 |
| 8 | 9 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 10 | 1859 | 17 | 1927 |
| 9 | 8 | 8 | 9 | 9 | 10 | 9 | 9 | 8 | 9 | 8 | 9 | 8 | 9 |
| 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 8 | 9 | 8 |
| 9 | 9 | 8 | 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 8 | 9 | 8 |
| 9 | 8 | 9 | 8 | 8 | 8 | 9 | 9 | 9 | 11 | 14 | 10 | 11 | 8 |
| 12 | 9 | 12 | 8 | 8 | 10 | 8 | 69 | 8 | 9 | 9 | 9 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 8 | 8 | 9 | 9 | 9 |
| 9 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 9 |
| 9 | 31 | 9 | 9 | 8 | 8 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 9 |
| 9 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 9 |
| 9 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 9 | 9 | 9 | 8 | 11 | 9 |
| 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 8 | 8 |
| 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 9 | 9 |
| 8 | 8 | 9 | 158 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 |

Plate 10

Subject 11

IR .008

Imp. 10

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 301 | 263 | 1943 | 18 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7 |
| 7 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 8 | 2216 | 2222 | 566 | 16 | 8 |
| 8 | 8 | 7 | 8 | 7 | 8 | 7 | 7 | 7 | 8 | 13 | 7 | 7 | 8 |
| 8 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 2537 | 2020 |
| 2066 | 269 | 11 | 7 | 8 | 8 | 7 | 8 | 8 | 7 | 8 | 7 | 7 | 8 |
| 7 | 7 | 8 | 7 | 8 | 8 | 8 | 8 | 7 | 7 | 8 | 7 | 8 | 8 |
| 7 | 8 | 7 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 8 | 8 | 7 |
| 8 | 8 | 7 | 8 | 7 | 7 | 8 | 7 | 7 | 8 | 7 | 8 | 7 | 7 |
| 7 | 8 | 7 | 8 | 7 | 8 | 7 | 8 | 7 | 7 | 7 | 8 | 7 | 8 |
| 7 | 8 | 7 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 8 |
| 7 | 8 | 28 | 8 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 8 | 7 | 8 |
| 7 | 8 | 7 | 8 | 8 | 7 | 8 | 7 | 8 | 7 | 8 | 8 | 7 | 8 |
| 9 | 8 | 8 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 8 | 7 | 8 | 7 |
| 7 | 8 | 8 | 7 | 8 | 8 | 7 | 8 | 7 | 8 | 8 | 8 | 7 | 7 |
| 8 | 8 | 8 | 8 | 7 | 8 | 7 | 7 | 7 | 8 | 8 | 7 | 7 | 7 |
| 8 | 7 | 8 | 8 | 7 | 262 | 122 | 8 | 211 | 8 | 7 | 7 | 8 | 7 |
| 8 | 8 | 8 | 8 | 7 | 8 | 8 | 8 | 7 | 8 | 7 | 7 | 7 | 8 |
| 7 | 8 | 7 | 7 | 7 | 7 | 8 | 7 | 7 | 8 | 7 | 7 | 8 | 7 |
| 7 | 8 | 7 | 8 | 7 | 8 | 7 | 7 | 8 | 7 | 8 | 8 | 7 | 8 |
| 7 | 8 | 8 | 7 | 7 | 8 | 7 | 8 | 8 | 7 | 7 | 8 | 7 | 8 |
| 8 | 8 | 7 | 8 | 7 | 8 | 8 | 7 | 7 | 8 | 7 | 8 | 8 | 8 |
| 8 | 8 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7 | 7 |
| 8 | 7 | 7 | 7 | 7 | 8 | 8 | 16 | 7 | 7 | 8 | 8 | 7 | 7 |
| 8 | 7 | 7 | 8 | 8 | 7 | 7 | 8 | 8 | 8 | 10 | 8 | 7 | 7 |

Plate 11

Subject 12

IR .009

Imp. 9

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 20 | 1385 | 2637 | 2686 | 2791 | 15 | 9 | 9 | 8 | 9 | 9 | 8 | 9 |
| 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 1211 | 2160 | 1197 | 10 | 10 | 8 |
| 10 | 1125 | 8 | 9 | 9 | 9 | 8 | 9 | 23 | 9 | 9 | 9 | 9 | 9 |
| 8 | 9 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 2384 | 2751 | 2124 | 2772 | 9 |
| 9 | 9 | 8 | 9 | 9 | 8 | 8 | 561 | 8 | 8 | 8 | 8 | 8 | 187 |
| 8 | 7 | 8 | 7 | 8 | 8 | 8 | 7 | 8 | 7 | 7 | 8 | 8 | 7 |
| 118 | 7 | 8 | 8 | 10 | 8 | 8 | 7 | 8 | 8 | 8 | 8 | 7 | 7 |
| 8 | 8 | 8 | 8 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7 | 8 |
| 7 | 8 | 8 | 8 | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 8 | 13 | 9 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 7 | 8 | 8 | 7 | 8 |
| 7 | 7 | 8 | 7 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 8 | 8 | 8 |
| 8 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 8 |
| 7 | 8 | 8 | 7 | 7 | 7 | 8 | 8 | 7 | 7 | 7 | 8 | 7 | 7 |
| 7 | 7 | 8 | 8 | 8 | 7 | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 7 |
| 8 | 8 | 7 | 8 | 8 | 8 | 7 | 8 | 8 | 9 | 8 | 8 | 7 | 7 |
| 7 | 7 | 10 | 8 | 7 | 8 | 7 | 7 | 8 | 8 | 7 | 7 | 8 | 8 |
| 8 | 7 | 7 | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 8 | 7 | 8 | 7 |
| 7 | 7 | 7 | 8 | 7 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 7 | 7 |
| 7 | 7 | 7 | 8 | 7 | 7 | 7 | 8 | 17 | 8 | 8 | 7 | 8 | 7 |
| 7 | 7 | 7 | 8 | 8 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 8 | 7 |
| 7 | 8 | 8 | 7 | 8 | 7 | 8 | 7 | 7 | 8 | 8 | 7 | 7 | 8 |
| 7 | 7 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 |
| 7 | 7 | 7 | 8 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| 8 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 7 |

Plate 12

Subjeot 13

IR .010

Imp. 46

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 679 | 1685 | 177 | 14 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 11 |
| 10 | 11 | 10 | 10 | 10 | 10 | 11 | 10 | 11 | 1196 | 1100 | 11 | 11 | 11 |
| 10 | 10 | 10 | 11 | 11 | 12 | 18 | 574 | 20 | 13 | 12 | 11 | 12 | 11 |
| 11 | 10 | 11 | 11 | 10 | 92 | 10 | 10 | 13 | 10 | 25 | 1346 | 1987 | 1234 |
| 10 | 11 | 11 | 10 | 10 | 11 | 10 | 10 | 11 | 10 | 11 | 10 | 11 | 10 |
| 10 | 9 | 10 | 11 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 11 | 9 |
| 10 | 10 | 10 | 10 | 9 | 10 | 10 | 9 | 9 | 11 | 10 | 11 | 11 | 11 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 |
| 10 | 9 | 10 | 11 | 10 | 10 | 10 | 9 | 9 | 10 | 13 | 10 | 9 | 10 |
| 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 10 | 9 |
| 9 | 11 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 10 |
| 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 9 | 10 | 11 |
| 10 | 10 | 10 | 10 | 10 | 9 | 11 | 10 | 10 | 9 | 10 | 10 | 10 | 11 |
| 10 | 10 | 10 | 10 | 10 | 10 | 11 | 9 | 10 | 10 | 9 | 10 | 9 | 10 |
| 10 | 10 | 10 | 10 | 9 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 9 | 10 |
| 9 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 9 | 10 | 10 |
| 10 | 10 | 10 | 10 | 9 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 9 | 10 | 10 | 10 | 9 | 10 | 10 | 12 | 10 | 10 | 11 |
| 10 | 9 | 10 | 10 | 10 | 10 | 11 | 11 | 10 | 11 | 9 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 9 | 10 | 10 | 10 | 9 | 10 |
| 10 | 10 | 10 | 9 | 9 | 10 | 10 | 10 | 11 | 9 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 10 |

Plate 13

Subject 14

IR .012

Imp. 42

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 67 | 2463 | 2438 | 15 | 10 | 11 | 11 | 10 | 11 | 13 | 11 | 10 | 11 | 11 |
| 10 | 12 | 12 | 12 | 11 | 11 | 11 | 10 | 12 | 10 | 2303 | 2410 | 267 | 12 |
| 10 | 10 | 10 | 11 | 11 | 13 | 9 | 11 | 10 | 10 | 11 | 12 | 11 | 13 |
| 11 | 11 | 12 | 11 | 11 | 10 | 11 | 10 | 10 | 10 | 10 | 11 | 10 | 2309 |
| 2497 | 2189 | 135 | 14 | 11 | 10 | 12 | 11 | 10 | 17 | 11 | 11 | 10 | 12 |
| 12 | 11 | 10 | 10 | 10 | 11 | 10 | 11 | 12 | 11 | 11 | 10 | 11 | 12 |
| 12 | 11 | 11 | 11 | 11 | 11 | 10 | 12 | 10 | 11 | 11 | 11 | 10 | 10 |
| 10 | 10 | 11 | 11 | 10 | 11 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 11 | 12 | 11 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 10 | 11 | 11 | 11 |
| 12 | 12 | 11 | 10 | 10 | 12 | 11 | 11 | 10 | 11 | 11 | 11 | 11 | 10 |
| 12 | 10 | 10 | 11 | 11 | 10 | 11 | 11 | 11 | 11 | 12 | 11 | 10 | 11 |
| 10 | 11 | 10 | 11 | 11 | 11 | 10 | 12 | 11 | 10 | 10 | 11 | 10 | 11 |
| 10 | 10 | 10 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 11 | 10 | 11 | 11 |
| 10 | 10 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 10 | 10 |
| 12 | 11 | 12 | 11 | 11 | 11 | 10 | 13 | 11 | 11 | 11 | 12 | 10 | 11 |
| 10 | 11 | 11 | 10 | 12 | 12 | 11 | 10 | 11 | 11 | 11 | 10 | 10 | 10 |
| 9 | 11 | 11 | 11 | 10 | 10 | 11 | 10 | 11 | 10 | 11 | 11 | 10 | 11 |
| 10 | 11 | 12 | 12 | 11 | 10 | 11 | 11 | 11 | 11 | 10 | 11 | 11 | 13 |
| 12 | 12 | 12 | 11 | 11 | 11 | 11 | 12 | 10 | 10 | 11 | 11 | 10 | 10 |
| 10 | 10 | 11 | 12 | 11 | 11 | 11 | 10 | 11 | 10 | 11 | 11 | 11 | 11 |
| 11 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 11 | 11 | 12 | 11 | 12 |
| 11 | 10 | 12 | 11 | 11 | 12 | 10 | 12 | 11 | 11 | 10 | 10 | 11 | 10 |
| 11 | 11 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 11 | 10 | 11 |
| 11 | 12 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 10 | 11 | 11 | 10 |

Plate 14

Subject 15

IR 11

Imp. 17

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2625 | 2658 | 31 | 93 | 11 | 13 | 13 | 13 | 10 | 10 | 10 | 12 | 8 | 7 |
| 10 | 11 | 10 | 11 | 10 | 12 | 10 | 10 | 2693 | 2687 | 10 | 12 | 10 | 12 |
| 10 | 11 | 14 | 8 | 7 | 10 | 10 | 13 | 10 | 12 | 12 | 11 | 10 | 11 |
| 13 | 14 | 12 | 11 | 14 | 10 | 10 | 14 | 10 | 10 | 17 | 2578 | 2450 | 2236 |
| 13 | 12 | 18 | 9 | 10 | 13 | 10 | 11 | 10 | 10 | 11 | 10 | 10 | 10 |
| 8 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 10 | 8 | 10 | 10 | 10 | 12 | 10 | 10 | 10 |
| 8 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 8 | 10 |
| 10 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 10 | 9 | 10 | 10 |
| 10 | 10 | 11 | 10 | 10 | 10 | 11 | 10 | 10 | 12 | 10 | 10 | 10 | 9 |
| 10 | 10 | 10 | 12 | 10 | 11 | 8 | 10 | 10 | 10 | 10 | 10 | 10 | 11 |
| 10 | 10 | 10 | 10 | 10 | 9 | 11 | 10 | 9 | 9 | 10 | 10 | 8 | 10 |
| 10 | 11 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10 | 11 | 10 | 10 | 11 | 9 | 10 | 8 | 10 | 11 | 7 | 10 | 10 | 10 |
| 10 | 10 | 9 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 10 |
| 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 10 | 9 |
| 10 | 10 | 10 | 10 | 12 | 10 | 10 | 12 | 9 | 10 | 9 | 10 | 9 | 13 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 8 | 10 | 10 |
| 10 | 10 | 9 | 8 | 10 | 10 | 10 | 10 | 9 | 10 | 11 | 10 | 9 | 10 |
| 16 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 7 | 10 | 10 | 10 | 9 | 9 |
| 9 | 10 | 10 | 8 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 11 | 10 | 10 |
| 10 | 10 | 10 | 9 | 11 | 10 | 10 | 8 | 8 | 9 | 10 | 10 | 10 | 9 |
| 10 | 10 | 10 | 10 | 8 | 9 | 9 | 9 | 10 | 9 | 10 | 10 | 10 | 10 |

Plate 15

Subject 16

IR .009

Imp. 26

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 547 | 1612 | 951 | 218 | 11 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 1156 | 2269 | 54 | 197 | 9 |
| 10 | 9 | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 9 |
| 8 | 9 | 8 | 9 | 12 | 8 | 9 | 8 | 8 | 8 | 9 | 70 | 1105 | 1853 |
| 1344 | 305 | 11 | 122 | 8 | 9 | 9 | 8 | 8 | 46 | 9 | 8 | 8 | 8 |
| 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 8 | 9 | 8 |
| 9 | 9 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 |
| 8 | 9 | 8 | 8 | 9 | 8 | 8 | 9 | 9 | 9 | 8 | 8 | 9 | 8 |
| 9 | 9 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 15 | 9 | 8 |
| 9 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 8 | 8 |
| 9 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 |
| 9 | 9 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 8 |
| 9 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 9 | 8 | 8 | 8 |
| 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 |
| 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 8 | 8 |
| 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 9 |
| 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 8 | 8 | 8 |
| 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 9 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 9 | 9 | 8 | 8 |
| 9 | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 |
| 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 8 |
| 9 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 |
| 8 | 9 | 8 | 8 | 8 | 8 | 9 | 8 | 9 | 8 | 8 | 8 | 9 | 8 |
| 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 8 | 9 |

Plate 16

Subject 17

IR .011

Imp. 10

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3082 | 2796 | 152 | 52 | 48 | 92 | 43 | 41 | 40 | 40 | 74 | 70 | 65 | 62 |
| 57 | 56 | 56 | 52 | 13 | 11 | 12 | 12 | 3021 | 2928 | 127 | 20 | 19 | 40 |
| 25 | 11 | 12 | 10 | 10 | 13 | 10 | 11 | 9 | 11 | 10 | 11 | 10 | 10 |
| 10 | 10 | 9 | 10 | 10 | 11 | 10 | 10 | 10 | 10 | 2837 | 2672 | 2576 | 9 |
| 11 | 10 | 11 | 11 | 10 | 11 | 11 | 11 | 10 | 21 | 10 | 9 | 9 | 9 |
| 10 | 11 | 9 | 10 | 9 | 11 | 9 | 9 | 9 | 9 | 9 | 11 | 10 | 9 |
| 11 | 9 | 9 | 8 | 10 | 10 | 9 | 9 | 9 | 10 | 11 | 9 | 10 | 9 |
| 10 | 9 | 9 | 10 | 9 | 11 | 9 | 11 | 9 | 11 | 9 | 9 | 10 | 9 |
| 9 | 11 | 9 | 9 | 11 | 9 | 10 | 9 | 10 | 9 | 9 | 9 | 10 | 9 |
| 11 | 9 | 11 | 9 | 11 | 9 | 11 | 9 | 11 | 9 | 9 | 9 | 10 | 9 |
| 9 | 9 | 11 | 9 | 9 | 11 | 9 | 9 | 11 | 9 | 9 | 9 | 10 | 9 |
| 9 | 11 | 10 | 9 | 11 | 9 | 11 | 9 | 10 | 9 | 10 | 10 | 9 | 9 |
| 11 | 10 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 10 | 11 | 9 | 11 |
| 9 | 10 | 11 | 9 | 9 | 9 | 10 | 9 | 9 | 8 | 10 | 9 | 9 | 9 |
| 9 | 9 | 11 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 11 | 9 | 9 |
| 9 | 9 | 9 | 9 | 9 | 11 | 10 | 10 | 9 | 9 | 10 | 9 | 11 | 10 |
| 11 | 9 | 9 | 9 | 11 | 9 | 10 | 10 | 9 | 9 | 10 | 9 | 11 | 9 |
| 9 | 11 | 9 | 9 | 9 | 11 | 9 | 11 | 9 | 9 | 9 | 11 | 9 | 11 |
| 9 | 9 | 9 | 11 | 9 | 10 | 9 | 11 | 10 | 9 | 9 | 10 | 9 | 8 |
| 9 | 10 | 9 | 10 | 10 | 9 | 10 | 9 | 11 | 9 | 9 | 9 | 10 | 9 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 8 | 9 | 9 |
| 11 | 8 | 11 | 9 | 10 | 9 | 11 | 9 | 10 | 9 | 10 | 9 | 9 | 9 |
| 11 | 9 | 11 | 9 | 10 | 8 | 9 | 10 | 9 | 9 | 9 | 9 | 9 | 9 |
| 10 | 9 | 9 | 9 | 11 | 9 | 10 | 9 | 9 | 10 | 10 | 9 | 9 | 10 |

Plate 17

Subject 18

IR .009

Imp. 16

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 280 | 104 | 39 | 53 | 49 | 50 | 46 | 29 | 9 | 9 | 9 | 9 | 9 |
| 10 | 10 | 9 | 10 | 10 | 14 | 9 | 8 | 390 | 816 | 103 | 109 | 40 | 36 |
| 20 | 20 | 10 | 10 | 15 | 10 | 11 | 11 | 10 | 11 | 11 | 16 | 10 | 11 |
| 9 | 9 | 11 | 9 | 10 | 9 | 12 | 9 | 8 | 9 | 317 | 582 | 539 | 601 |
| 318 | 33 | 18 | 10 | 9 | 11 | 9 | 26 | 9 | 8 | 10 | 10 | 8 | 9 |
| 9 | 9 | 9 | 10 | 10 | 9 | 9 | 9 | 8 | 10 | 8 | 10 | 8 | 9 |
| 9 | 9 | 10 | 9 | 10 | 9 | 14 | 9 | 10 | 10 | 10 | 8 | 10 | 10 |
| 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 8 | 9 | 9 |
| 9 | 9 | 8 | 10 | 9 | 10 | 9 | 8 | 8 | 8 | 9 | 9 | 8 | 9 |
| 10 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 14 | 9 | 9 |
| 9 | 9 | 8 | 8 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 9 | 9 | 8 | 8 | 9 | 9 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 |
| 9 | 9 | 9 | 10 | 8 | 8 | 8 | 9 | 9 | 9 | 8 | 8 | 9 | 9 |
| 8 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 10 | 8 | 8 | 8 | 8 | 8 |
| 9 | 8 | 9 | 9 | 9 | 8 | 9 | 8 | 8 | 10 | 9 | 8 | 8 | 9 |
| 8 | 9 | 8 | 9 | 8 | 8 | 9 | 10 | 9 | 8 | 8 | 9 | 8 | 9 |
| 10 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 |
| 9 | 9 | 9 | 9 | 8 | 8 | 8 | 9 | 9 | 8 | 9 | 10 | 9 | 9 |
| 9 | 9 | 9 | 8 | 9 | 9 | 10 | 9 | 9 | 9 | 8 | 9 | 9 | 8 |
| 8 | 8 | 8 | 8 | 9 | 10 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 8 |
| 9 | 9 | 9 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8 |
| 9 | 9 | 10 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 10 | 9 | 9 | 8 |
| 8 | 9 | 9 | 9 | 9 | 10 | 8 | 8 | 9 | 9 | 9 | 8 | 9 | 9 |
| 8 | 8 | 9 | 9 | 8 | 8 | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 9 |

Plate 18

# APPENDIX B

TABLE V

RAW SCORE FOR SUBJECTS
WITH RESPECT TO THE
OBJECTIVE SKILLS TESTS

| Subject | Dyer | Miller-Broer | Cobane |
|---|---|---|---|
| 1 | 32 | 87 | 36 |
| 2 | 31 | 58 | 0 |
| 3 | 30 | 41 | 36 |
| 4 | 21 | 11 | 20 |
| 5 | 38 | 90 | 24 |
| 6 | 20 | 53 | 32 |
| 7 | 25 | 94 | 24 |
| 8 | 16 | 37 | 16 |
| 9 | 20 | 41 | 18 |
| 10 | 30 | 35 | 30 |
| 11 | 19 | 37 | 34 |
| 12 | 29 | 31 | 8 |
| 13 | 36 | 35 | 47 |
| 14 | 29 | 53 | 14 |
| 15 | 17 | 28 | 16 |
| 16 | 28 | 35 | 30 |
| 17 | 39 | 60 | 24 |
| 18 | 18 | 49 | 44 |

TABLE VI

T SCORES FOR SUBJECTS WITH RESPECT TO THE OBJECTIVE SKILLS TESTS

| SUBJECT | DYER | MILLER-BROER | COBANE | TOTAL |
|---|---|---|---|---|
| 1 | 54 | 66 | 56 | 176 |
| 2 | 53 | 54 | 40 | 147 |
| 3 | 53 | 47 | 56 | 156 |
| 4 | 47 | 34 | 49 | 130 |
| 5 | 58 | 67 | 51 | 176 |
| 6 | 45 | 52 | 54 | 151 |
| 7 | 49 | 69 | 51 | 169 |
| 8 | 43 | 45 | 47 | 135 |
| 9 | 46 | 47 | 48 | 141 |
| 10 | 53 | 44 | 53 | 150 |
| 11 | 45 | 45 | 55 | 145 |
| 12 | 52 | 43 | 44 | 139 |
| 13 | 57 | 44 | 47 | 148 |
| 14 | 52 | 52 | 46 | 150 |
| 15 | 44 | 41 | 47 | 132 |
| 16 | 51 | 44 | 53 | 148 |
| 17 | 59 | 55 | 51 | 165 |
| 18 | 44 | 50 | 59 | 153 |

# APPENDIX C

TABLE VII

SUBJECTS' SUCCESS
IN SEVEN MATCHES OF
TOURNAMENT SINGLES COMPETITION

| SUBJECT | GAMES WON | GAMES LOST | PERCENTAGE |
|---|---|---|---|
| 1 | 38 | 28 | .58 |
| 2 | 26 | 38 | .41 |
| 3 | 36 | 36 | .50 |
| 4 | 22 | 43 | .34 |
| 5 | 42 | 12 | .78 |
| 6 | 27 | 28 | .49 |
| 7 | 44 | 12 | .79 |
| 8 | 10 | 38 | .21 |
| 9 | 18 | 32 | .36 |
| 10 | 28 | 26 | .52 |
| 11 | 42 | 20 | .68 |
| 12 | 18 | 37 | .33 |
| 13 | 34 | 30 | .53 |
| 14 | 36 | 28 | .56 |
| 15 | 11 | 42 | .21 |
| 16 | 21 | 41 | .34 |
| 17 | 39 | 29 | .57 |
| 18 | 43 | 12 | .78 |

# APPENDIX D

TABLE VIII

SUBJECTS' PERFORMANCE WITH RESPECT TO THE THREE MEASURES OF THE STUDY

| Subject | Skill Tests | Tournament Success | Relaxation |
|---|---|---|---|
| 1 | 176 | .58 | 25 |
| 2 | 147 | .41 | 350 |
| 3 | 156 | .50 | 1,729 |
| 4 | 130 | .34 | 335 |
| 5 | 176 | .78 | 25 |
| 6 | 151 | .49 | 340 |
| 7 | 169 | .79 | 25 |
| 8 | 135 | .21 | 20 |
| 9 | 141 | .36 | 130 |
| 10 | 150 | .52 | 375 |
| 11 | 145 | .68 | 20 |
| 12 | 139 | .33 | 35 |
| 13 | 148 | .53 | 490 |
| 14 | 150 | .56 | 1,729 |
| 15 | 132 | .21 | 335 |
| 16 | 148 | .34 | 25 |
| 17 | 165 | .57 | 910 |
| 18 | 153 | .78 | 820 |

# APPENDIX E

## DESCRIPTIONS OF THE OBJECTIVE SKILLS TESTS IN TENNIS

### Revised Backboard Test of Tennis Ability

Equipment:

1. Backboard or wall, approximately ten feet in height and allowing about fifteen feet in width per person taking the test at one time.

2. On this wall a plainly visible line three inches in width, to represent the net, should be drawn so that the top is three feet from the ground.

3. A restraining line, five feet from the base of the wall, should be drawn on the floor.

4. Stop watch with a second hand.

5. Two balls and a racket per player. It is desirable that the balls be in good condition, although it is not essential that they be exactly new. The racket should be without flaws.

6. Box for extra balls, about 12 inches long, 9 inches wide and 3 inches deep, placed on the floor where the restraining line joins the side at the left for right-handed players and right for left-handed players.

7. One pencil per group of four players.

8. Score card per player.

Organization:

Divide the group to be tested into units of four players each, and number them from one to four. Provide each player with a score card on which she writes her name. Then read the following description of the test to the group.

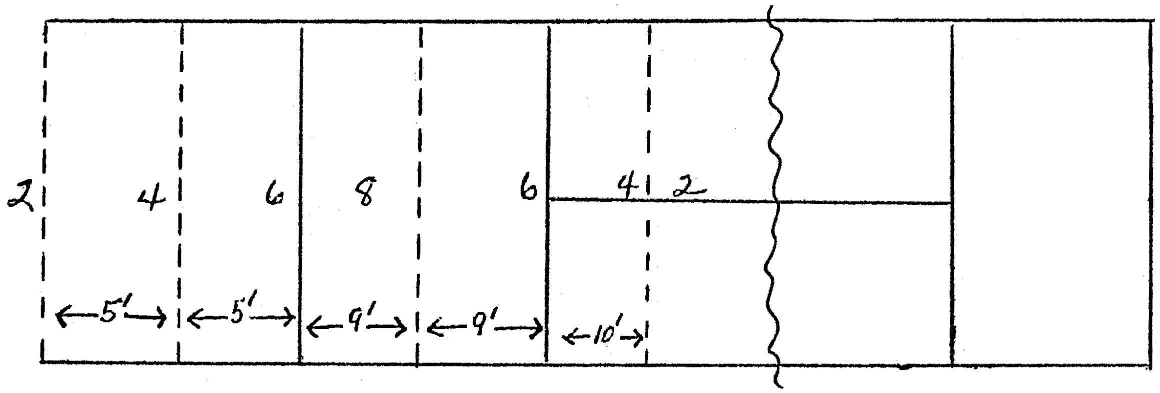
The Backboard Test consists in rallying a tennis ball against the wall. The object of the test is to cause the ball to strike the wall on or above the net line as many times as you can in 30 seconds. When I say 'Go!' start the test immediately. Drop the ball and let it hit the floor once, then put it in play against the wall. Continue to play it against the wall until I say 'Stop!' at the end of thirty seconds. There is no limit to the number of times the ball may bounce before you hit it. You may volley the ball. The ball need not touch the floor before you play it except at the start when a new ball is being put in play. You may use any stroke or combination of strokes. You must play all balls from behind this restraining line (indicate the line clearly). You may cross the line to retrieve balls, but any hits made while in such a position do not count. You may use any number of balls. If for any reason you lose control of the ball in play, do not try to retrieve it. Take another ball from this box (indicate clearly) and put it in play as you did at the start. Each ball striking the wall on or above the net line before the word 'Stop!' counts as a hit end scores one point. You will be given three trials today. The final score on the test is the sum of the scores on the three trials.

Validity: .85 - .92 with experts' rating and scores in a round robin tournament.

Reliability: .86 - .92 with chance halves and test-retest.

Miller-Broer Forehand-Backhand Drive Test

Court Markings:




Equipment:

1. One regulation court.

2. One regulation net with a rope stretched four feet above the top of the net.

3. One racket and 15-20 balls in good condition.

4. Score sheets for each player and pencils.

5. Special court markings (see figure above).

Directions:

1. The player taking the test stands behind the baseline, bounces the balls to herself, hits the balls and attempts to place them in the back nine feet of the opposite court.

2. Each player is allowed fourteen trials on the forehand and fourteen trials on the backhand.

3. In order to score, the balls must go between the top of the net and the rope and land in the designated area or on lines bounding the area (balls landing on a line receive the highest score for that area).

4. Balls which go over the rope score one-half the value of that area in which they land.

5. If the player misses the ball in attempting to strike it, it is considered a trial.

6. Let balls are taken over.

Scoring:

1. Each ball hit is scored 2-4-6-8-6-4-2, depending upon the area in which it lands. Note: Each ball going over the rope is scored one-half the value of the area in which it lands.

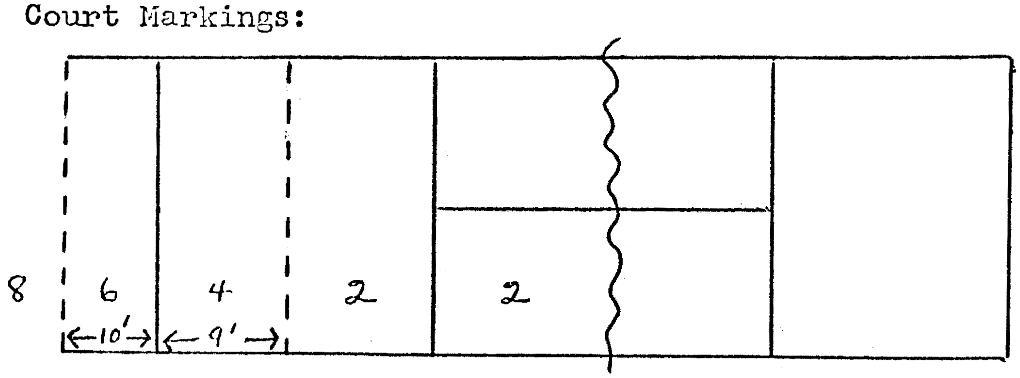
2. The total score equals the sum of fourteen balls on the forehand and fourteen balls on the backhand.

Validity: .61 for beginners - .85 for intermediates --with judges ratings.

Reliability: .80 - with split halves stepped up with the Spearman-Brown Prophecy Formula.

Cobane Test for the Service

Court Markings:



Directions:

The student stands behind the baseline on the right-hand side of the court and serves 14 balls, attempting to have them land in the correct service court. Left-handed students serve from the left side of the court. Each serve that lands in the correct court is considered successful and is scored as to force. Each serve landing outside the court is unsuccessful and is given a score of zero. Let balls are reserved.

The scoring for force is determined by where the ball lands on its second bounce. A second bounce that lands either in the service court or within an area nine feet beyond the service line is given a score of two. A second bounce landing between the nine-foot line and the baseline is scored as four; between the baseline and a line ten feet beyond the baseline as six; beyond this ten-foot line as eight. A ball landing on a line is scored as landing in the farther of the two areas involved.

Validity: Face

Reliability: .87

# APPENDIX F

TRANSCRIPTION OF THE TAPE OF DIRECTIONS FOR THE TESTING OF SUBJECTS' ABILITY TO RELAX MUSCULAR TENSION

I want you to listen closely to the directions and follow them carefully. On the signal of "go", you are going to bend your arm at the elbow and tense your biceps muscle as hard as you possibly can. You are going to hold this maximum contraction for a period of ten seconds, after which I will give you the signal to stop. At this signal you will let your arm fall limply back onto the table, slowly uncurling your fingers and trying to get all of the tension out of the muscle. Notice as you tense it the feeling of tightness, the tension, that is present in the muscle, and when you relax try to eliminate all of this tenseness. Alright, are you ready? Go. (Ten second period of contraction.) Stop. Uncurl the fingers. Let your arm relax. Try to get all the feeling of tightness out of the muscle. (One minute period of relaxation.)

Alright, we're going to try it again. This time we're going to turn on the sound. You can actually hear the electrical impulses as they are given out by the machine. After you have tensed the muscle, I want you to listen to the sound and try to eliminate it completely, so that there is total silence. Again, on the signal "go" you will tense the muscle as hard as possible and hold it for ten seconds. On stop you will let your arm fall limply, uncurl your fingers and try to completely relax the biceps muscle. Are you ready? Go. (Ten second period of contraction.) Stop. Let the hand fall limply, uncurl your fingers. Try to relax the muscle, no sound on the machine. (One minute period of relaxation.)

Once again for the last time. This time as you tense the muscle try to really feel the tension and when you relax it try to release all the tension that you felt in the muscle. Ready, go. (Ten second period of contraction.) Stop. Relax. Let it fall limply. Uncurl the fingers. All the tension out of the muscle. Just relax as completely as possible.

The rest of the period will be spent in your trying to achieve and maintain total silence in the muscle, or to relax it completely. No more directions will be given, you will simply, by lying there, attempt to relax the muscle as completely as possible striving for silence on the machine.

APPENDIX G

Subject____________ T Score Total__________

| Dyer | | Miller-Broer Forehand | Miller-Broer Backhand | Cobane |
|---|---|---|---|---|
| ______ | 1. | ________ | ________ | ______ |
| ______ | 2. | ________ | ________ | ______ |
| ______ | 3. | ________ | ________ | ______ |
| Total: | 4. | ________ | ________ | ______ |
| | 5. | ________ | ________ | ______ |
| | 6. | ________ | ________ | ______ |
| | 7. | ________ | ________ | ______ |
| | 8. | ________ | ________ | ______ |
| | 9. | ________ | ________ | ______ |
| | 10. | ________ | ________ | ______ |
| | 11. | ________ | ________ | ______ |
| | 12. | ________ | ________ | ______ |
| | 13. | ________ | ________ | ______ |
| | 14. | ________ | ________ | ______ |
| | Totals: | | | Total: |

Total: ____________

Plate 19: Sample of the score card utilized on administering the objective skill tests in tennis.

Group 1

| | | | | | |
|---|---|---|---|---|---|
| 1 vs 2 | 6-1 | 2 vs 1 | ______ | 3 vs 1 | ______ |
| 1 vs 3 | 4-6 | 2 vs 3 | ______ | 3 vs 2 | ______ |
| 1 vs 4 | ______ | 2 vs 4 | ______ | 3 vs 4 | ______ |
| 1 vs 5 | ______ | 2 vs 5 | ______ | 3 vs 5 | ______ |
| 1 vs 6 | ______ | 2 vs 6 | ______ | 3 vs 6 | ______ |
| 1 vs | ______ | 2 vs | ______ | 3 vs | ______ |
| 1 vs | ______ | 2 vs | ______ | 3 vs | ______ |
| Totals: | | | | | |
| %: | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 4 vs 1 | ______ | 5 vs 1 | ______ | 6 vs 1 | ______ |
| 4 vs 2 | ______ | 5 vs 2 | ______ | 6 vs 2 | ______ |
| 4 vs 3 | ______ | 5 vs 3 | ______ | 6 vs 3 | ______ |
| 4 vs 5 | ______ | 5 vs 4 | ______ | 6 vs 4 | ______ |
| 4 vs 6 | ______ | 5 vs 6 | ______ | 6 vs 5 | ______ |
| 4 vs | ______ | 5 vs | ______ | 6 vs | ______ |
| 4 vs | ______ | 5 vs | ______ | 6 vs | ______ |
| Totals: | | | | | |
| %: | | | | | |

Plate 20: Sample of the score card utilized for recording the tournament success of subjects.