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Twenty-one women students enrolled in an intermediate tennis class were used as subjects in this study to determine the effects of certain psychic stressors inherent in competition on the discriminatory-reaction and movement time of the tennis forehand and backhand backswings. This time was measured with a specially constructed apparatus consisting of an electrical stimulus unit, a photo-electric response unit, and an electrical timing unit.

A total of seven testings took place. The first three established the base conditions and the next four were the experimental conditions of individual competition, team competition, self-competition and spectator observation. A Fisher's "t" test was used as the statistical treatment to determine the significance of difference between the means of the base testings and the four experimental conditions, and between the means of the four experimental conditions.

The analyses of these data revealed that there was a significant improvement between the mean base score and the experimental situations of individual, team, and self-competition. Further analyses indicated a significant difference between the experimental conditions of individual competition and self-competition, team competition and spectator observation, and self-competition and spectator observation.

These findings would seem to indicate that the

stressors inherent in some types of competition can improve the discriminatory-reaction and movement time associated with tennis and that perhaps this improvement might enhance tennis playing ability.

THE EFFECT OF THE PSYCHOLOGICAL COMPONENTS OF COMPETITION ON REACTION TIME IN TENNIS

by

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CHAPTER I

INTRODUCTION AND STATEMENT OF PROBLEM

Whether it be a corner sand lot rivalry, a squad scrimmage in a physical education class, an intramural activity, or an intense intercollegiate contest, competition is one of the most important underlying ingredients which dominates the game. Inherent within all games, regardless of the level of skill, is the competitive element.

Recognizing this, the teacher of sport and games has an obligation to investigate what effect, if any, competition has on both the players themselves and their performance. Often it has been the opportunity of physical education teachers or coaches to see in some students a relaxed, smooth, rhythmic movement pattern in practice, and then to see this pattern change at the last minute into awkward motions when the same students are involved in an intense competitive situation. Also, situations are frequently seen where the students perform only moderately well during a practice period, but when placed in a highly competitive situation their grace and ease of motion in the game distinguishes them as the "star."

Obvious to the observer is the apparent fact that the components of competition or the types of competition itself are responsible for bringing about this unexpected

performance. What are these components of competition, and what effects, if any, do they have on students?

Physical educators have been interested in many questions with regard to competition. Does the stress of competition cause a simple patterned reflex to become a complicated thought process? Does the stress of competition cause simple decision making to become awkward ineffective moments of hesitation or indecision? Does competition speed up learned movement patterns? Does competition inhibit speed?

It was questions such as these, raised by the opportunity to participate in, coach, and observe many types of competitive athletics, which prompted the writer to undertake the following study to determine what effects certain psychic stressors inherent in competition have on the discriminatory-reaction and movement time of the tennis drive backswings.

STATEMENT OF PROBLEM

This study was conducted to determine what effects certain psychic stressors have on the discriminatory-reaction and movement time of the tennis forehand and backhand backswings as measured by a specially constructed electrical timing apparatus.

The study also proposed to compare four forms of competition to each other in order to determine which of these acted as the most intense stressor.

CHAPTER II

REVIEW OF LITERATURE

INTRODUCTION

The pertinent reviewed literature has been divided into four main areas; stress, psychic stressors, reaction time, and the relationship of psychic stressors and reaction time. Because of the voluminous amount of material available on the Stress Theory, this area has been reviewed only as it relates to this study. Particular emphasis has been placed on the psychological stressors of motivation and competition. From the reviewed material a working definition of competition and its motivating components has been formulated. Emphasis has also been placed on the factors affecting reaction time, particularly the psychic stressors.

STRESS

Stress as defined by Selye is ". . . the state manifested by a specific syndrome which consists of all the non-specifically induced changes within a biologic system." (9:54) These changes, referred to as the General Adaptation Syndrome, are brought about by non-specific agents known as **stressors.**

Selye (9) has theorized that the General Adaptation Syndrome is manifested by three phases: (1) the alarm

reaction during which the body recognizes a stressor as present and begins to draw upon the defensive forces in the organism, (2) the stage of resistance during which through neural and endocrine stimulation the various systems of the body act against the stressors, and (3) the state of exhaustion during which the body is unable to regain its homeostatic balance and exhauston or death occurs.

The General Adaptation Syndrome mechanism affects virtually every system in the body; the main regulators being the brain, nerves, pituitary gland, thyroid gland, adrenal gland, liver, kidney, blood vessels, connective tissue, and white blood cells. During the stage of resistance the nerves, through both the stimulation of the adrenal medulla and their own nature, produce an increase of adrenaline and acetylcholine. These substances stimulate the pituitary gland. The pituitary produces three hormonal substances, adrenocorticotropic hormone (ACTH), somatotropic hormone (STH), and thyrotropic (TTH). ACTH stimulates the adrenal cortex to produce anti-inflamatory corticoids which reduces the number of white blood cells, stimulates growth of connective tissue, stimulates the liver to destroy or transform the corticoids, and increases the blood pressure by stimulating the kidney to produce renal pressor substance. It is thought that the STH stimulates the adrenal cortex to produce pro-inflamatory corticoids. The third hormone, TTH, stimulates the thyroid gland which influences

general body metabolism.

The General Adaptation Syndrome may be brought about by stressors either physical or psychological in nature. Selye stated that ". . . any one agent is more or less a stressor in proportion to the degree of its ability to produce stress, that is non-specific changes." (9:64) The exact pathway of the stressor is not known, but the theory of selective conditioning, in which people react differently to various stressors according to their inherited and acquired characteristics, is one suggested by Selye (9).

The process of adapting to these stressors requires a certain amount of energy, called by Selye (9) adaptation energy. When this energy is used by a local system, exhaustion occurs in that system, thus causing more energy to be obtained from other reserves or sources in other parts of the body. When all of an individual's adaptibility or energy is used up, the General Adaptation Syndrome becomes irreversible and exhaustion and death occur. Although it is not known exactly what adaptation energy might be, one of the postulates concerning such energy is that a person is endowed with a certain amount at birth, depending on genetic background.

Man can adjust to many stressors, but upon continued uninterrupted exposure the adaptation energy is finally exhausted. This theory suggests that there might be some relationship between the general adaptation energy and aging.

Man has some choice as to the use of adaptation energy. A rather uneventful life would cause little energy to be used, whereas a more stressful life could utilize more. Man can not lead a stressless life, but according to Selye (9) he can learn to conserve and cope with the sometimes damaging effects of stress.

As has been noted, the stress response may be elicited by both physical and psychic stressors. The studies reviewed in this section relate to the particular stressors of motivation and competition.

In relation to the stressors of competition and motivation, Lazurus et. al. concluded that ". . . stress occurs when a particular situation threatens the attainment of some goal." (26:295) The report pointed out that the type of motivation, the method of approach a subject makes to the situation, and the effects of strong emotion are all factors which influence a person's response to a stress situation. Selye indicated that "Heredity, age, previous exposure to stress, nervous stimuli, the nutritional state, and many other factors can affect both the production of the adaptive hormones and their effect on individual target organs." (31:627)

Michael reviewed studies conducted in relation to exercise and stress and found that the studies supported the theory that repeated exercise conditions the stress adaptation mechanism. He noted that

> The studies pointed out that the adrenocortical activity along with the autonomic nervous system are involved in adjusting to stress. This ability to adjust is helped with exercise if we assume that the more sensitive response to stress reduces the time necessary to elicit a response and therefore lessens the duration of the adjusting phase. The evidence indicates that adaptation to exercise produces a degree of protection against emotional stress. The increased adrenal activity resulting from repeated exercise seems to cause an increased reserve of streiods available to counter stress. A lack of activity was reported to reduce the ability to withstand stress, as if the reaction to a shock is a "learned" process. (28:53)

In a study concerned with exercise and stress, Massey (40) found that physiological changes associated with stress occurred in college women following the exercise program demanded by the Harvard Step Test.

A great deal of research has been conducted to determine the effects of the emotional stressor of motivation upon performance. In a study dealing with motivational stressors, Ulrich and Burke (35) found that motivational techniques produce a greater work output than no motivation, and that those situations suggesting success produce greater gross mechanical efficiency than those operational situations which were neutral or suggested failure.

Nelson (41) used different motivational techniques to determine their effects on physical performance testings. He found that normal instructions, instructor interest and verbal encouragement did not alter significantly performance levels, while competition, fictitious situations, presence of an observer, and ego-involvement did alter performance

levels.

In a study to investigate the effects of motivation upon performance in a learning and performance task, Zimny (48) found that incentive instructions had a significant effect only through the first half of the test, but such effects were not apparent when the entire task was considered, thus suggesting that motivation of incentive instructions to be transitory.

A considerable amount of work has been done dealing with the effect of competition as a motivator and a stressor. By measuring the galvanic skin response, systolic and diastolic blood pressure and pulse rate, Harmon and Johnson (17) found the emotional states of football and track athletes changed before a competitive event and that this change varied according to the importance of the game.

When the emotional states of football players and wrestlers were measured before a competitive event Johnson (22) found that wrestlers have more pregame change than do the football players. He postulated that this might be due to wrestling being an individual sport where the success or failure of the event was dependent entirely upon the individual participant. He also observed that those wrestlers who reported extreme tension prior to a match had less effective performance than those reportedly not as tense.

By using various types of competition as incentives for sixth grade children Strong (33) found that competition

using levels of aspiration and team membership increased performance on physical fitness tests significantly more than did competition against self, against someone of nearly equal ability, against someone of markedly different ability, and competition to establish class records.

In a study of junior-senior high school boys and girls of both high and low motor ability, Stitt (45) used competition based on individual incentive, class incentive, school incentive, and no incentive. She reported that individual and class incentive improved performance on gross motor activities, but added that when selecting competitive type incentives, age and maturation level should be an important consideration.

In a study to determine how competition affects performance, in terms of quanity and quality of a simple task involving both mental and motor capacities of college students, Whittemore (36) found that more work, but of poorer quality, was turned out when there was competition than when the subjects were not competing. He also reported greater fluctuation of individual performance with no competition as compared to performance with competition. Whittemore (36) noted that there was no difference in results when material rewards were offered and concluded that the student's desire to excel was sufficient to bring forth their best efforts.

Ulrich through employing various levels of competition for college women found that the anticipation, participation,

and denial of these stressors elicited the stress response. She concluded that

> In each instance the stress elicited in individuals (1) varies from situation to situation, (2) is related to psychological components in the stressor situation to a far greater degree than it is related to the components involving physical activity, and (3) is related to identifiable differences in past experiences which are relevant to the situation. (46:130)

It has been noted that competition as a stressor has an effect on both emotional and physical performance.

At this point it would serve to develop a working definition of competition and to determine its inherent components.

Edwards (12) stated that courage, loyalty, determination, joy in exercise, satisfaction in skills, and sensitivity to life are all components in competition.

Cannon said that spectator approval works on the emotion of athletes and produces measurable physiological changes. He also noted that

> . . . in the hazardous sports, in mountain climbing, in the hunting of big game, and in the tremendous adventure of war, risks, and excitement and the sense of power surge up together, setting free unsuspected energies and bringing vividly to consciousness memorable fresh revelations of the possibility of achievement. (2:230)

The need for self esteem and ego-defense, said Lazurus et. al. (26) may tend to make a person center his attention on the goal wanted to maintain esteem, or it may tend to make the person leave the field and thus have the excuse of not trying.

For the purposes of this study, competition is defined as a motivated, goal-oriented endeavor which predisposes opposition. The motivating components inherent in competition are (1) the desire to achieve, (2) the desire for approval, (3) the desire to prove superiority, (4) the desire for self-realization, and (5) the desire to gain prestige. Competition is an emotional, psychic stressor which elicits the stress response.

REACTION TIME

Reaction time is the time elapsing between the application of the stimulus to a sensory receptor until the moment of response. This term is applied to those responses of a conscious nature. Those responses of an unconscious nature are referred to as reflex times. According to Karpovich (6) there is some relation between reaction and reflex times and it is often impossible to differentiate between reaction time and conditioned reflex times.

According to Morehouse and Miller

> . . . a reflex is an invariable predictable response to stimulation of a particular type of receptor, and the response always accomplishes a useful purpose that is related to the nature of the stimulus. (7:34)

The neurophysiological functionings of a reflex originate in the spinal cord. This impulse travels along a motor nerve membrane fiber by means of local electrical currents until it reaches the junction of the nerve fiber and muscle fiber. Here it releases a chemical known as acetylcholine

which is responsible for transmitting the excitation to the muscle membrane. This substance is then destroyed by the enzyme cholinesterase. It is still not known how the muscle membrane distributes the excitation over the length of the muscle fiber.

The voluntary muscle acts which are associated with reaction time originate from certain areas in the cerebral cortex. The impulses from the cortex travels through the corticospinal tract where most of the fibers cross to the opposite sides of the medulla and result in the left side of the cortex controlling movement on the right side of the body and the right side of the cortex controlling muscle movements on the left side of the body. The cerebellum coordinates these activities by being constantly supplied by stimuli which indicate the position and action of the muscles and joints. Karpovich (6) maintained that most of this guidance and coordination is purely reflex.

Morehouse and Miller (7) differentiate the volitional from the reflex activity by the unpredictable nature of the volitional response. This unpredictability is attributed to the type of stimulus and to the past experiences of the person. They added that thought slows down the response to stimuli and even occassionally misinterprets the stimuli and gives an inappropriate response.

When transmitting an impulse, a neuron obeys the all-or-none law. That is, when the stimulus reaches a certain

threshold the impulse is transmitted. When the stimulus is greater than threshold value, although it has no effect on the quality of the impulse, it may irradiate and cause contraction of adjacent neurons. According to Rasch and Burke (8) the varying muscle responses are not due to the stimulus intensity but rather to the number of neurons stimulated and the frequency of these stimulations.

When an impulse travels from one neuron to another it crosses a synapse. Rasch and Burke suggested that

> Because of their variable resistance, synapses may tend to be selective and to direct the pathway of the nervous impulse, nervous impulses resulting from feeble stimuli being conducted across only the synapses with low resistance, but nervous impulses resulting from powerful stimuli crossing those with high resistance as well. (8:100)

For this reason any impulse may tend to follow the path of least resistance.

Reaction time is affected by many variables including age, sex, fatigue, activity involvement, and stimuli. Hodgkins (20), Karpovich (6), and Morehouse and Miller (7) reported that the fastest reaction times are between the ages of twenty-one and thirty. Teichner indicated that "Reaction time is a slowly falling growth function of chronological age until thirty years after which it is a slowly rising function." (34:144)

Karpovich (6) and Morehouse and Miller (7) concluded that men have faster reaction times than women. This has been supported by Teichner (34). Hodgkins (20) also found

that men have faster reaction times, but that women maintain their peak speed longer than men.

Because of the suggested importance of reaction time to success in athletics many studies have been conducted to determine the reaction times of athletes as compared to non-athletes. These studies (3) (32) (47) (29) (38) (43) conducted with high school and college men supported the hypothesis that athletes do have the faster reaction time. In one of the few studies dealing with the reaction times of women athletes as compared to non-athletes, Youngen (37) found that the athletic group was significantly faster than the non-athletic group.

Knapp (25) in a study comparing reaction time of top class racket players to research students found a highly significant difference in favor of the racket players. She suggested that this factor may be one of the prerequisites to the players success.

Morehouse and Miller (7) said that reaction time is affected by the nature of the stimulus, and that the stimuli of sound and touch result in faster reaction times than do visual stimuli. Slater Hammel (32) and Wilkenson (47) both report that subjects had faster times with a kinesthetic stimulus than with a visual stimulus.

In a study conducted to determine the effect of motor oriented and stimulus oriented sets on reaction time and speed of arm movements of college men and women, Henry (18)

found that the motor set, in which the subjects were asked to concentrate on the desired movement, caused slower reaction time and speed of arm movement than the sensory set, in which the subjects were asked to concentrate on the given stimulus, and that there seems to be a natural tendency among individuals to prefer either the sensory or motor set. From this evidence Henry (18) postulated that thought slows down response speed.

In a study dealing with the effect of task complexity upon reaction time response, O'Brien (42) found that the more complex the succeeding task, the slower was the reaction time. He also observed that athletes do not have faster reaction times in activities resembling the sports in which they excel.

Teichner summarized that "Reaction time is not related to the length, direction, or speed of movement of the responding member." (34:144) This is in accord with studies (38) (20) which reported there to be no significant relationship between reaction time and speed of movement.

Most of the studies reviewed were concerned with simple reaction time. That is, the time elapsing between a stimulus and a given single response. According to Oleson, (29) stimuli that call for the subject to choose between two possible responses are referred to as choice reaction times, and those that require the subjects to choose from among three or more responses are known as discriminatory-reaction

times.

PSYCHIC STRESSORS AND REACTION TIME

The effect of excitement, fear, anxiety, and tension associated with emotional stress, particularly as it relates to competition, upon reaction time and speed of movement is of particular concern to physical educators and athletic coaches. Does motivation, especially that of competition, increase or impair muscle performance, reaction time, or speed of movement?

DeVries (4) indicated that under normal conditions of activity only a certain number of the available motor units are used. However, when emotional excitement occurs, increased hypothalamus activity increases the number of motor units used and this, plus the increase in the amount of adrenaline supplied by the nerves to the muscle fiber, activates possible antagonists of the desired movement and may result in performance decrements.

Rasch and Burke (8) supported the view of DeVries (4) by stating that ". . . the removal of excess general tension minimizes the output of irrelevant motor impulses, allowing the conditioned reflexes for contraction and inhibition to occur." (8:115) They indicated that the expert performer is more strongly conditioned in patterns of contraction and inhibition than the beginner and thus the expert performers are bothered by only the more intense stressors.

Morehouse and Miller stated that

> The degree of muscular tension during the performance of an activity affects the energy requirement of the task, the rate of movement of body parts, and the onset of fatigue. (7:56)

They also recognize that tension is affected by both mental and emotional experiences.

When a choice or discriminatory response is called for, Grice indicated that

> In cases where the correct response is initially weaker in habit strength than competing responses, or where there are such a large number of competing responses that there is a high probability of one or more of them being stronger that the correct one at any particular instant, increases in motivation should lead to performance decrements. (16:71)

In agreement with this, Castaneda and Palermo (11) suggested that if the habit strengths of correct responses are greater than the incorrect responses, increase in drive will result in a facilitation of performance, however, if the incorrect responses are greater than the correct responses, then a drive increase should result in impairment of performance.

Farber and Spence (14) conducted a study on the effect of anxiety on reaction time and found that reaction time was unaffected by anxiety which was produced by the stress of an electric shock or the stimulus complexity of bright and dim lights. They measured anxiety by the Taylor Manifest Anxiety Score.

Kamin and Clark (23), by using the Taylor's Manifest Anxiety Score, found that subjects with reportedly high anxiety had both slower simple reaction times and motivated reaction times, which dealt with the avoidance of electric

shock, than those subjects with reportedly low anxiety. Castaneda (10), dealing with reaction time and response amplitude as a function of buzzer stimulus intensity, and anxiety as measured by the Taylor's Manifest Anxiety Score, found a significant increase in both reaction time and amplitude when the stimulus intensity increased. He also found that the high anxiety group tended to be slower at the weak intensity stimuli and faster at the high intensity stimuli than the low anxiety group.

A study conducted by Henry (18) revealed that using light intensity and electric shock as motivators significantly improved the reaction time and movement time of college men. Henry (18) attributed this improvement to the informative value of the stimuli rather than to the punishment of the shock or to a direct facilitative function.

Ryan (30) found that increased tension impairs performance of a difficult motor task, but facilitates performance of a simple motor task. In a study conducted with male college athletes, Howell (21) found that both the tense and non-tense, as measured by heart rate, blood pressure, breathing rate, and skin resistance, improved significantly in the complete motor response when being motivated by a shock prevention apparatus.

Although the findings of the reviewed studies on the effect of psychic stressors on reaction time are contradictory, it appears that the effect is dependent on the

stimulus, the type of motivation, and the intensity of the stressor.

SUMMARY

This review of literature has been concerned with the stress theory, types of stressors, particularly those of motivation and competition, reaction time, and the effects of psychic stressors on reaction time. The psychic stressors of motivation and competion can bring about the stress response which causes certain physiological changes known as the General Adaptation Syndrome. It was found that psychic stressors have an effect on reaction time, but few studies have been conducted on the effect of competition as a stressor on reaction time. As competition is inherent in athletics and physical education, and reaction time is an important factor in athletic success, the need to study the effects of competition on reaction time seemed pertinent.

CHAPTER III

PROCEDURES

STATEMENT OF PURPOSE

The purpose of this study was to find the effects of certain psychic stressors inherent in competition on the discriminatory-reaction times of the tennis forehand and backhand backswing.

SELECTION OF SUBJECTS

Twenty-one women students enrolled in an intermediate tennis class at the University of North Carolina at Greensboro second semester, 1966-1967, were selected as subjects. The class met two times a week at nine o'clock in the morning. The ages of the students ranged from eighteen to twenty-one years. From stated information from the class, it was determined that all of the students had had experience in beginning tennis classes and had had some recreation, class, intramural, or extramural competitive tennis experience.

SELECTION OF TESTING EQUIPMENT

For the purposes of this study, the time elapsing between the stimulus of either a right and left light signal and the desired reaction-movement response from a specific stance will be referred to as the discriminatory reaction

and movement time. In order to measure this time an electrical machine capable of measuring the stipulated forehand and backhand tennis backswings had to be devised. With the helpful and understanding assistance of the University of North Carolina at Greensboro electrician, Mr. Gordon Lavers, an apparatus consisting of a stimulus unit, response unit, and timing unit was constructed.

The stimulus unit consisted of two seventy-five watt light bulbs that could be seen through right and left directional arrow openings in the front of a wood panel. These openings were twenty-eight inches apart. The operation of these lights was controlled by microswitches located in the back of the panel. Also located in the back of the panel was a momentary non-locking switch, which when activated simultaneously with the light switch, opened the circuit of the timing unit. The unit used for timing was the Hunter's Model 120A Klockkounter. The clock was connected to the apparatus via inputs one, two, six and eight located in the back of the clock. This connection produced a short circuit between the clock and the response unit making it possible to obtain a composite score for each subject by reducing the usual time drag of the clock.

The response unit consisted of a photo-electric cell, a Model 1A Kodislide projector with a one hundred fifty watt bulb, and a small two inch by three inch floor mirror. This apparatus was located twelve feet six inches from the front

of the stimulus unit and was directly centered. The photo-electric cell which produced its own voltage of between 3.3 and 4.5 was mounted to a wooden arm brace which extended six and a half feet from the floor. Located directly under the photo-electric cell was a wooden platform on which was placed the projector and mirror. This arrangement permitted the beam of light to be projected vertically to the floor. When the beam was broken by a backswinging racket, the timing unit was closed, thus stopping the clock. Because of the large width of the beam and the necessity of all the light diffusion being broken at once, black cotton material and black cardboard were wired and taped over the racket strings and narrow racket handle. A complete electrical circuit drawing and placement diagram of the apparatus may be found in the Appendix.

TEST ADMINISTRATION

With the assistance of two graduate physical education majors trained in the use of the testing apparatus, a total of seven testing situations took place. Before the testing began, one class period was allotted for the explanation and demonstration of the testing procedure to the subjects. The subjects were then allowed practice trials. A diagram of the subjects positioning in relation to the testing apparatus may be found in the Appendix. The following instructions explained the total movement pattern to the subjects to facilitate their ability to simulate the

backswing of the forehand and backhand tennis drives.

> Stand with your feet parallel and a comfortable distance apart facing the light panel. The racket is to be held in a ready position so that the face of the racket is parallel to the floor and centered over the tape line in front of you. Upon receiving the light stimulus, the racket is to be swung back in a linear plane approximately one hundred eighty degrees so that it passes through the photo-electric beam. If you are right handed, take a forehand backswing when the right light appears and a backhand backswing when the left light appears. If you are left handed, take a forehand backswing when the left light appears and a backhand backswing when the right light appears. This backswing must be accompanied with a step backwards in the direction of the swing. Once the beam has been broken, return to the ready position and await the next stimulus.

Each testing consisted of ten trials of five backhand swings and five forehand swings. The order of these trials varied from testing to testing but remained constant for all subjects during each particular testing period. It was necessary to change the order of the trials to prevent the possibility of the subjects learning the sequences. The order of these trials was determined by coin tossing. The order of the trials may be found in the Appendix.

Each of the seven testings was administered at the beginning of the tennis class for which the students enrolled. The first three testings were used to obtain a mean base score. Every effort was made to reduce the number of stressors affecting the subjects during the first three testing periods. The only people in the laboratory during these base testings were the two assistants who operated the testing apparatus. The subjects were instructed to do their

best and to respond as quickly as possible.

The next four testings were constructed to provide a competitive situation and elicit an anticipated response conditioned by stress. In order to determine the psychic stressors of competition, it was necessary to formulate a definition of competition and its inherent components. References pertaining to competition (12) (36) (45) (22) were studied and conferences were held with professors in the Physical Education Department at the University of North Carolina at Greensboro, to discuss the components of competition. It was decided that for the purposes of this study competition would be defined as a motivated, goal-oriented endeavor which pre-disposes opposition. The components considered to be inherent in competition were (1) the desire for achievement, (2) the desire for approval, (3) the desire to prove superiority, (4) the desire for self-realization, and (5) the desire to gain prestige. The four experimental conditions devised were individual competition, team competition, self-competition, and competition involving spectator observation.

The first situation involved individual competition against the other individuals in the class. The subject was sent alone to the testing laboratory where she was told her mean base score. As a motivational reward, the subject was told that the one person who improved more than any other member in class in relation to lowering her own base score

would be given a dinner for two at the restuarant of her choice. Besides competing against other individuals in the class, it was recognized that this testing also included some degree of self-competition as the subject was also competing against a composite score previously established during her first three testing sessions.

The second experimental situation was one of team competition. The class, all meeting in the laboratory at once, was equally divided by a split-ranking of mean base scores into two teams, red and blue. The testing alternated from an individual on one team to an individual on the opposite team, with both the individual and team scores being announced after each subject's testing. It was announced that the winning team, the one which had the lowest composite score, would be rewarded with coffee and doughnuts.

The third situation involved self-competition. Before the testing session began, each subject was told her best previous score. Knowing this score, she was encouraged to take pride in her performance and was urged to put forth her best efforts in order to perform at her best. Throughout the testing the subject received verbal encouragement from both the instructor and the two assistants who were administering the test.

The fourth situation was concerned with spectator observation. Members of the staff of the Physical Education Department, graduate physical education majors, undergraduate

physical education majors, and selected service class students of the University of North Carolina at Greensboro were invited to attend this testing. Before this testing began, the subjects were encouraged by the instructor to perform better than they ever had on previous testings. In addition they were told that the spectators would be moving in and out of the laboratory and would be observing individual performance. The spectators were not given any instructions as to their conduct at the testing although they realized that the situation was experimental in nature and that their presence was intended to add a psychological stressor to the testing situation. During this testing the measuring apparatus began to operate inconsistently and several subjects were required to repeat the sequence. It was quite possible that the malfunctioning of the machine produced as much stress on the subjects as did the presence of the spectators.

RECORDING THE DATA

The discriminatory-reaction and movement time was recorded on individual five by eight inch index cards. A sample of this score card may be found in the Appendix. The recorded scores were read directly from the Hunter clock and were recorded to the nearest thousandth of a second.

SUMMARY

In order to fulfill the purpose of this study and determine the effects of certain psychic stressors inherent

in competition on the discriminatory-reaction and movement times of the backswing of the tennis forehand and backhand strokes, it was necessary to construct a machine capable of measuring this time. Twenty-one women students enrolled in an intermediate tennis class were chosen as subjects. Three control testing situations and four competitive testing situations involving individual competition, team competition, self competition, and competition with spectator competition were administered to the subjects, thus yielding a total of seven individual scores.

CHAPTER IV

PRESENTATION OF DATA

In order to measure the effects of certain psychic stressors inherent in competition on the discriminatory-reaction and movement times of tennis drives, seven experimental testings took place with a specially constructed timing apparatus. The subjects used for this study were twenty-one women students enrolled in an intermediate tennis class at the University of North Carolina at Greensboro, spring semester, 1967.

The first three testings recorded were considered the base scores, and the arithmetical mean of these scores was computed yielding what was termed the mean base score. These raw scores and means may be found in Table I.

The next four testings were conducted under competitive situations of individual competition, team competition, self-competition, and competition involving spectator observation.

Null hypotheses were stated with regard to the relationship between the base test score and each of the competitive test scores. The first null hypothesis established was:

(1) There is no significant difference between the discriminatory-reaction and movement times of tennis forehand and backhand backswings when

TABLE I

RAW SCORES AND MEAN OF THE
THREE BASE TESTINGS

Subject	First Testing Seconds	Second Testing Seconds	Third Testing Seconds	Means
1.	7.605	8.780	8.477	8.287
2.	9.531	7.813	9.772	9.038
3.	9.155	7.288	7.281	7.908
4.	8.470	9.134	9.908	9.170
5.	8.693	10.278	9.771	9.580
6.	10.444	9.473	11.073	10.330
7.	9.760	8.153	9.643	9.185
8.	9.201	7.766	10.434	9.133
9.	7.592	7.676	9.234	8.167
10.	8.850	7.798	9.108	8.585
11.	10.250	9.754	10.199	10.067
12.	8.554	6.244	6.809	7.195
13.	9.949	7.937	8.672	8.852
14.	12.231	8.301	8.976	9.836
15.	12.576	9.193	8.705	10.158
16.	9.641	9.594	9.293	9.509
17.	9.755	8.336	8.335	8.808
18.	9.449	8.540	9.634	9.207
19.	9.317	9.774	7.875	8.988
20.	7.999	8.906	8.993	8.632
21.	10.428	9.129	10.005	9.854

performed without the psychic stressors of individual competition and these discriminatory-reaction and movement times when performed with the psychic stressor of individual competition.

The Fisher's "t" test for correlated means was used to ascertain the significance of difference between the mean base score and the experimental condition. The differences between mean and their "t" values may be found in Table II. A five percent level of confidence was deemed acceptable to indicate a statistically significant change between the control testing and the experimental testing.

This hypothesis was rejected at the one percent level of statistical confidence. From the data, it was assumed that the stressor of individual competition did significantly change the discriminatory-reaction and movement times of the group that was tested.

The second null hypothesis established was:

(2) There is no significant difference between the discriminatory-reaction and movement times of the tennis forehand and backhand backswings when performing without the psychic stressor of team competition and these discriminatory-reaction and movement times when performing with the psychic stressor of team competition.

The Fisher's "t" test for correlated means was used to determine the significance of difference between the mean base score and the experimental condition of team competition. The differences between means and their "t" values may be found in Table II. A five percent level of confidence was deemed acceptable to indicate a statistically significant change between the control testing and the

TABLE II

THE SIGNIFICANCE OF DIFFERENCE BETWEEN THE MEAN BASE SCORE AND INDIVIDUAL COMPETITION, TEAM COMPETITION, SELF-COMPETITION, AND SPECTATOR OBSERVATION

Test	Mean Difference	"t"
Individual Competition	-.6923	4.1233*
Team Competition	-1.0801	9.0324*
Self-Competition	-1.1187	6.2047*
Spectator Observation	-.2250	.6543

experimental testing.

The hypothesis was found not tenable at the one percent level of statistical confidence. It should be noted that because of absences from the class during the testing involving team competition, the data analyzed with this testing have three less scores than do the other experimental tests. From these data, it can be assumed that the stress of participation in team competition was intense enough to change the discriminatory-reaction and movement times of the group tested.

The third null hypothesis established was:

(3) There is no significant difference between the discriminatory-reaction and movement times of the tennis forehand and backhand backswings when performing without the psychic stressor of self-competition and these discriminatory-reaction and movement times when performing with the psychic stressor of self-competition.

The Fisher's "t" test for correlated means was used to ascertain the significance of difference between the mean base score and the experimental condition. The differences between means and their "t" values may be found in Table II. A five percent level of confidence was deemed acceptable to indicate a statistically significant change between the control testing and the experimental testing.

This hypothesis was not found tenable at the one percent level of statistical confidence. From the data, it would appear that self-competition as a stressor is intense enough to produce a change significantly different from

chance in the discriminatory-reaction and movement times.

The fourth null hypothesis established was:

(4) There is no significant difference between the discriminatory-reaction and movement times of the tennis forehand and backhand backswings when performing without the psychic stressors of spectator observation and these discriminatory reaction and movement times when performing with the psychic stressors of spectator observation.

The Fisher's "t" test for correlated means was used to determine the significance of difference between the mean base score and the experimental condition. The difference between the means and their "t" values may be found in Table II. A five percent level of confidence was accepted to indicate a statistically significant change between the control testing and the experimental testing.

The hypothesis was found tenable for the difference between the mean scores of no competition involving spectator observation and competition involving spectator observation.

In order to determine if any of the four forms of competition produced a mean which was significantly different with regard to discriminatory-reaction and movement time, null hypothesis were established with regard to the relationships of these four competitive situations. The hypotheses were:

(1) There is no significant difference between the psychic stressors of individual competition and team competition.

The Fisher's "t" test for correlated means was used

to find the significance of difference among the scores. The differences between the means and their "t" values may be found in Table III. A five percent level of confidence was again taken to indicate statistically significant differences among the relationships of the four competitive situations.

This hypothesis was found tenable.

(2) There is no significant difference between the psychic stressors of individual competition and self-competition.

The Fisher's "t" test for correlated means was used to find the significance of difference among the scores. The differences between the means and their "t" values may be found in Table III. A five percent level of confidence was taken to indicate statistically significant differences among the relationships of the four competitive situations.

This hypothesis was found not tenable at the five percent level of confidence.

(3) There is no significant difference between the psychic stressors of individual competition and competition under spectator observation.

The Fisher's "t" test for correlated means was used to find the significance of difference among the scores. The differences between the means and their "t" values may be found in Table III. A five percent level of confidence was taken to indicate a statistically significant difference between this relationship.

This hypothesis was found tenable.

TABLE III

THE SIGNIFICANCE OF DIFFERENCE BETWEEN THE FOUR EXPERIMENTAL TESTINGS

Test	Mean Difference	"t"
Individual Competition: Team Competition	-.3906	1.0435
Individual Competition: Self-Competition	-.4263	2.2401**
Individual Competition: Spectator Observation	+.4673	1.6420
Team Competition: Self-Competition	-.1106	.6647
Team Competition: Spectator Observation	+.9383	2.5777**
Self-Competition: Spectator Observation	+.8937	2.5745**

* Significant at the one percent level of confidence
** Significant at the five percent level of confidence

(4) There is no significant difference between the psychic stressors of team competition and competition under spectator observation.

A Fisher's "t" test for correlated means was used to find the significance of difference among the scores. The differences between the means and their "t" values may be found in Table III. A five percent level of confidence was taken to indicate a statistically significant difference between this relationship.

This hypothesis was found tenable.

(5) There is no significant difference between the psychic stressors of team competition and competition under spectator observation.

A Fisher's "t" test for correlated means was used to find the significance of difference among the scores. The differences between the means and their "t" values may be found in Table III. A five percent level of confidence was taken to indicate a statistically significant difference between this relationship.

This hypothesis was found not tenable at the five percent level of confidence.

(6) There is no significant difference between the psychic stressors of self-competition and competition under spectator observation.

The Fisher's "t" test for correlated means was used to find the significance of difference among the scores. The differences between the means and their "t" values may be found in Table III. A five percent level of confidence was taken to indicate a statistically significant difference

between this relationship.

The hypothesis was found not tenable at the five percent level of confidence.

SUMMARY

Null hypotheses were established regarding the significance of difference between the discriminatory-reaction and movement times of the tennis forehand and backhand backswings when not involved in competition and these times when involved with the psychic stressors of individual competition, team competition, self-competition, and competition under spectator observation. A five percent level of confidence was assumed to be significant of statistical difference between these variable. The Fisher's "t" test for correlated means was used to determine the significance of this difference.

This statistical analysis revealed that there was a significant difference between the mean base score and the experimental situations of individual competition, team competition and self-competition. There was no significant difference between the mean base score and the experimental condition of spectator observation.

Null hypotheses were also established regarding the significance of differences among the four competitive situations of individual competition, team competition, self-competition, and competition under spectator observation.

The Fisher's "t" test for correlated means was used to determine the significance of difference of these scores and the five percent level of confidence was judged to be indicative of significant statistical differences.

A statistically significant difference was found between the variables of individual competition and self-competition, team competition and spectator observation, and self-competition and spectator observation.

CHAPTER V

INTERPRETATION OF DATA

In order to compare the base testing to the four experimental testings a single score had to be chosen to represent the three base scores. It seemed unlikely to chose one of the single base scores because of uncontrollable physiological conditions such as fatigue or uncertain psychic stressors which might have been impinging on the subjects. The first score would have been especially unrealistic to use for even though the subjects had been introduced to the testing apparatus it is possible that the apparatus or the testing situation itself produced some degree of stress. It was decided after reviewing literature dealing with reaction time (43) (42) (38) that the mean would be the most accurate score to represent the base testings.

When the five motivating components of competition, that is, the desires for achievement, approval, superiority, self-realization, and prestige, were selected and summarized from reviewed literature and conferences held with persons experienced with competition, it was decided that the four experimental conditions of individual competition, team competition, self-competition, and competition involving spectation observation would best represent and include these

components. Besides being the most amenable to measurement, the four conditions seemed to encompass the various types of competitive situations in which a competitor might find himself.

It should be noted that when dealing with studies involving motivational techniques each situation will not necessarily serve to motivate each subject equally, but every effort was made to encourage or challenge each subject to the same extent. The subjects were also assured that their grades or class standing would not be affected by their performance on the testings.

When the mean base score was statistically compared with the four experimental conditions by use of the Fisher's "t" test it was found that the scores made during individual, team, and self-competition had significantly changed from the mean base score.

The mean of individual competition was decreased, that is the discriminatory-reaction and movement time was faster than it had been during the base testings. An interpretation of these data might suggest that when an individual feels his prestige or status threatened or when he is presented with the opportunity to achieve recognition and obtain a reward, the motivation is strong enough as a stressor to improve the discriminatory-reaction and movement time of the tennis forehand and backhand backswings.

The improvement of performance when involved in team

competition could suggest that when a person becomes a member of a team which is working toward a common goal, the stressors are great enough to improve the discriminatory-reaction and movement times of the tennis forehand and backhand backswing. This is in agreement with Stitt (45) and Strong (33) who both found that team membership significantly improved physical performance on fitness tests and gross motor activities.

The psychic stressors involved with self-competition were also strong enough to significantly improve the discriminatory-reaction and movement time. Although there was no extrinsic reward offered with this testing situation, apparently such a reward was not necessary to aid performance. This is in agreement with Whittemore (36) who found that the student's desire to excel was sufficient to bring forth their best efforts. The challenge to better their own performance was sufficient to decrease the discriminatory-reaction and movement time of the forehand and backhand backswings.

When competition involving spectator observation was statistically compared to the mean base score it was found that the spectator observation resulted in the slowest time. Although Cannon (2) reported that athletes did have measurable physiological changes associated with stress from spectator approval, there could be several explanations for this slower time. As has been reported, the testing apparatus

functioned erratically during this testing and several of the subjects were required to repeat the trials several times. These additional trials could have produced enough fatigue to significantly affect the scores.

It is also conceivable that the combined stress of the erratic machine and the spectators presence was sufficient to bring about an inhibitory response and result in a performance decrement. DeVries (4) indicated that increased emotional tension increases the number of motor units used and this plus the increase of adrenaline to the muscle fibers could possibly stimulate the antagonists of the desired movement and decrease muscle performance.

When the four experimental conditions were statistically compared with each other it was found that self-competition resulted in the fastest time and was significantly faster than individual competition and spectator observation. Perhaps in many competitive events the element of self-competition is one of the strongest psychological stressors or motivators. This could be seen in the case of the outstanding performer whose skill is so seldom challenged by others that the true challenge or satisfaction comes from the betterment of his own performance. Another situation might be described as the poorly skilled student who feels strongly the challenge of self-competition because, although he has little chance to actually win the event, the improvement of his own effort may be enough to sustain or motivate

further interest.

The stressors of team competition produced the second fastest measurable time and was significantly faster than the spectator observation. There was a greater improvement of scores with team competition than with individual competition, although this was not a significant improvement.

The comparisons of individual competition to team competition, individual competition to spectator observation, and team competition to self-competition produced no significant differences among these types of competition. This does not imply that the discriminatory-reaction and movement times will not vary under these types of competition because many competitive events are combinations of the above elements and not as isolated instances as were the laboratory operational situations.

In summarizing the effects of certain psychic stressors inherent in competition on the discriminatory-reaction and movement times of the tennis forehand and backhand backswings, it would appear that when compared to the mean base score, self-competition produced the fastest time, team competition the second fastest time, individual competition the third fastest time, and spectator observation the slowest time.

When the four experimental conditions were statistically compared to each other, it revealed a significant difference between the competitive situations of individual and

self, team and spectator, and self and spectator, but no significant difference between individual and team, individual and spectator, and team and self.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was conducted to determine the effects of certain psychic stressors inherent in competition on the discriminatory-reaction and movement times of the tennis forehand and backhand backswing. The subjects chosen were women students enrolled in an intermediate tennis class at the University of North Carolina at Greensboro.

A timing device consisting of an electric light stimulus unit, a photo-electric response unit, and a sensitive electric timing unit was constructed as the measuring apparatus. The subjects were given a total of seven testings, the first three situations consisted of the base testings and the next four were the experimental testings of individual competition, team competition, self-competition, and competition involving spectator observation.

A Fisher's "t" test was used to determine the significance of difference between the mean base score and the four experimental scores. A five percent level of confidence was taken to be indicative of a significant statistical difference between the scores. The analyses of this data revealed that:

(1) The stessors inherent in individual competition were strong enough to significantly improve the discriminatory-reaction and movement times of

the tennis forehand and backhand backswings.

(2) The stressors inherent in team competition were strong enough to improve the discriminatory-reaction and movement time of the tennis forehand and backhand backswings.

(3) The stressors inherent in self-competition significantly improved the discriminatory-reaction and movement times of the tennis forehand and backhand backswings.

(4) The stressors inherent in competition involving spectator observation were not strong enough to significantly change the discriminatory-reaction and movement times of the tennis forehand and backhand backswings.

These findings do not necessarily suggest that the improvement of discriminatory-reaction and movement time in individual, team, and self-competition would improve tennis play or performance, but such a conjecture is possible.

A Fisher's "t" test was also used to determine the significance of difference between each of the four experimental conditions of individual competition, team competition, self-competition, and competition involving spectator observation. A five percent level of confidence was deemed acceptable to indicate a significant difference in the scores.

The result of this statistical analyses revealed a statistically significant difference between the variables of individual competition and self-competition, team competition and competition involving spectator observation, and self-competition and competition involving spectator observation.

The statistical analyses did not show a significant

difference between the variable of individual competition and team competition, individual competition and competition involving spectator observation, and team competition and self-competition.

Although the data revealed an improvement of the discriminatory-reaction and movement times in three of the experimental conditions, it must be remembered that these were laboratory contrived situations and for actual competitive situations more consideration should be given to the degree of the performers involvement rather than to the type of competition itself. However, within the limitations of the interpretations imposed by the thesis, it can be suggested that competition will affect the timing of tennis strokes and such change may be reflected in the quality of play.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

1. Basowitz, Harold, et al. Anxiety and Stress. New York: McGraw-Hill, 1955.

2. Cannon, Walter B. Bodily Changes in Pain, Hunger, Fear, and Rage. New York: D. Appleton and Company, 1918.

3. Cureton, Thomas K. Jr. Physical Fitness of Champion Athletes. Urbana: University of Illinois Press, 1951.

4. DeVries, Herbert A. Physiology of Exercise. Dubuque, Iowa: Wm. C. Brown Company, 1966.

5. Gross, Nancy E. Living With Stress. New York: McGraw-Hill, 1958.

6. Karpovich, Peter V. Physiology of Muscular Activity. Fifth Edition, Philadelphia: W. B. Saunders Company, 1959.

7. Morehouse, Lawerence E. and Augustus T. Miller. Physiology of Exercise. St. Louis: The C. V. Mosby Company, 1963.

8. Rasch, Phillip J. and Roger K. Burke. Kinesiology and Applied Anatomy. Philadelphia: Lea and Febiger, 1963.

9. Selye, Hans. The Stress of Life. New York: McGraw-Hill Paperbacks, 1956.

B. PERIODICALS

10. Castaneda, A. "Reaction Time and Response Amplitude As A Function of Anxiety and Stimulus Intensity," The Journal of Abnormal Social Psychology, 53:225-228, 1956.

11. Castaneda, A., and D. S. Palermo. "Psychomotor Performance As A Function of Amount of Training and Stress," The Journal of Experimental Psychology,

50:175-179, 1955.

12. Edwards, M., and P. Neal. "Competition," The Journal of Health, Physical Education, and Recreation, 37:28-29, January, 1966.

13. Elbel, E. R. "A Study of Response Time Before and After Strenuous Exercise," The Research Quarterly, 11:86-95, May, 1940.

14. Farber, I. E. and K. W. Spence. "Effects of Anxiety, Stress, and Task Variable on Reaction Time," The Journal of Personality, 25:1-18, September, 1956.

15. Feffer, M. and L. Phillips. "Social Attainment and Performance Under Stress," The Journal of Personality, 22:284-297, 1963.

16. Grice, G. R. "Discrimination Reaction Time As A Function of Anxiety and Intelligence," The Journal of Abnormal Social Psychology, 50:71-74, 1950.

17. Harmon, J. M. and Warren R. Johnson. "The Emotional Reactions of College Athletes," The Research Quarterly, 23:391-397.

18. Henry, F. M. "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," The Research Quarterly, 23:43-54, 1952.

19. Henry, F. M. and D. E. Rogers. "Increased Response Latency For Complicated Movements and a 'Memory Drum' Theory of Neuromotor Reaction," The Research Quarterly, 31:448-458, 1960.

20. Hodgkins, Jean. "Reaction Time and Speed of Movement In Males and Females of Various Ages," The Research Quarterly, 34:335-343, October, 1963.

21. Howell, Maxwell L. "Influence of Emotional Tension On Speed of Reaction and Movement," The Research Quarterly, 24:22-32, 1953.

22. Johnson, Warren R. "A Study of Emotion Revealed In Two Types of Athletic Sports Contests," The Research Quarterly, 20:72-79, 1949.

23. Kamin, L. J. and J. W. Clark. "The Taylor Scale and Reaction Time," The Journal of Abnormal Social Psychology, 54:262-263, 1957.

24. Keller, Louis F. "The Relation of Quickness of Bodily Movement to Success in Athletics," The Research Quarterly, 13:146-155, May, 1942.

25. Knapp, B. N. "Simple Reaction Times of Selected Top-Class Sportsmen and Research Students," The Research Quarterly, 32:409-411, October, 1961.

26. Lazurus, R. S., J. Deese, and Sonia Osler. "Effects of Psychological Stress Upon Performance," The Psychological Bulletin, 49:293-317, 1952.

27. Marrazzini, A. S. "Messengers of the Nervous System," Scientific American, 196:86-90, February, 1957.

28. Michael, E. D. Jr. "Stress Adaptation Through Exercise," The Research Quarterly, 28:50-54, March, 1957.

29. Oleson, Einar A. "Relationship Between Psychological Capacities and Success in College Athletics," The Research Quarterly, 27:79-89, March, 1956.

30. Ryan, E. Dean. "Effects of Stress On Motor Performance and Learning," The Research Quarterly, 33:111-119, 1962.

31. Selye, Hans. "Stress and Disease," Science, 122:625-631, October 7, 1955.

32. Slater-Hammel, A. T. "Comparisons of Reaction-Time Measures to Visual Stimulus and Arm Movement," The Research Quarterly, 26:470, December, 1955.

33. Strong, Clinton H. "Motivation Related To Performance of Physical Fitness Tests," The Research Quarterly, 34:497-507, December, 1963.

34. Teichner, Warren H. "Recent Studies of Simple Reaction Time," The Psychological Bulletin, 51:128-149, March, 1954.

35. Ulrich, Celeste and Roger K. Burke. "Effects of Motivational Stress Upon Physical Performance," The Research Quarterly, 28:403-412, December, 1957.

36. Whittemore, Irving C. "Influence of Competition on Performance: An Experimental Study," The Journal of Abnormal Social Psychology, 19:236-254, 1924.

37. Youngen, Lois. "Comparison of Reaction and Movement Times of Women Athletes and Non-Athletes," The

Research Quarterly, 30:349-355, October, 1959.

C. UNPUBLISHED MATERIAL

38. Cooper, John Henry. "An Investigation of The Relationship Between Reaction Time and Speed of Movement." Unpublished Doctor's Dissertation, Indiana University, 1955.

39. King, Shirley. "Relaxation and Stress." Unpublished Master's Thesis, University of North Carolina, Greensboro, 1958.

40. Massey, Sally Ross. "A Study of the Stress Relationships Among and Within Individuals With Regard To Metabolic Rate and Cardiorespiratory Change." Unpublished Master's Thesis, University of North Carolina, Greensboro, 1957.

41. Nelson, Jack K. "An Analysis of the Effects of Applying Various Motivational Situations To A Stressful Physical Performance." Unpublished Master's Thesis, The University of Oregon, 1962.

42. O'Brien, Donald Edward. "The Relation Between Reaction Time and The Type and Complexity of the Succeeding Task," Unpublished Master's Thesis, Pennsylvania State University.

43. Rangazas, Ernest P. "A Comparative Analysis of Selected College Athletes and Non-Athletes on Several Hand-Foot Reaction Time Measures." Unpublished Master's Thesis, Indiana University.

44. Steitz, Edward S. "The Relationship of Reaction Time, Speed, Sargent Jump, Physical Fitness and Other Variables To Success In Specific Sports." Unpublished Doctor's Dissertation, Springfield College, 1963.

45. Stitt, E. A. "The Effects of Competitive Type Incentive Upon the Learning and Performance of Gross Motor Skills." Unpublished Doctor's Dissertation, University of Southern California, 1965.

46. Ulrich, Celeste. "Measurement of Stress Evidenced By College Women In Situations Involving Competition." Unpublished Doctor's Dissertation, University of Southern California, 1957.

47. Wilkinson, James J. "A Study of Reaction-Time Measures

To A Kinesthetic and a Visual Stimulus For Selected Groups of Athletes and Non-Athletes." Unpublished Doctor's Dissertation, Indiana University, 1958.

48. Zimny, George Henry. "The Effects of Certain Techniques of Inducing Motivation Upon A Learning and A Performance Task." Unpublished Doctor's Dissertation, University of Minnesota, 1952.

APPENDIX

APPENDIX A

SAMPLE SCORE CARD

NAME_____ AGE_____ CLASS_____

ADDRESS_____ TELEPHONE_____

UNC-G PHYSICAL EDUCATION CLASSES

1.
2.
3.
4.

TENNIS EXPERIENCE:

COMPETITIVE ATHLETIC EXPERIENCE

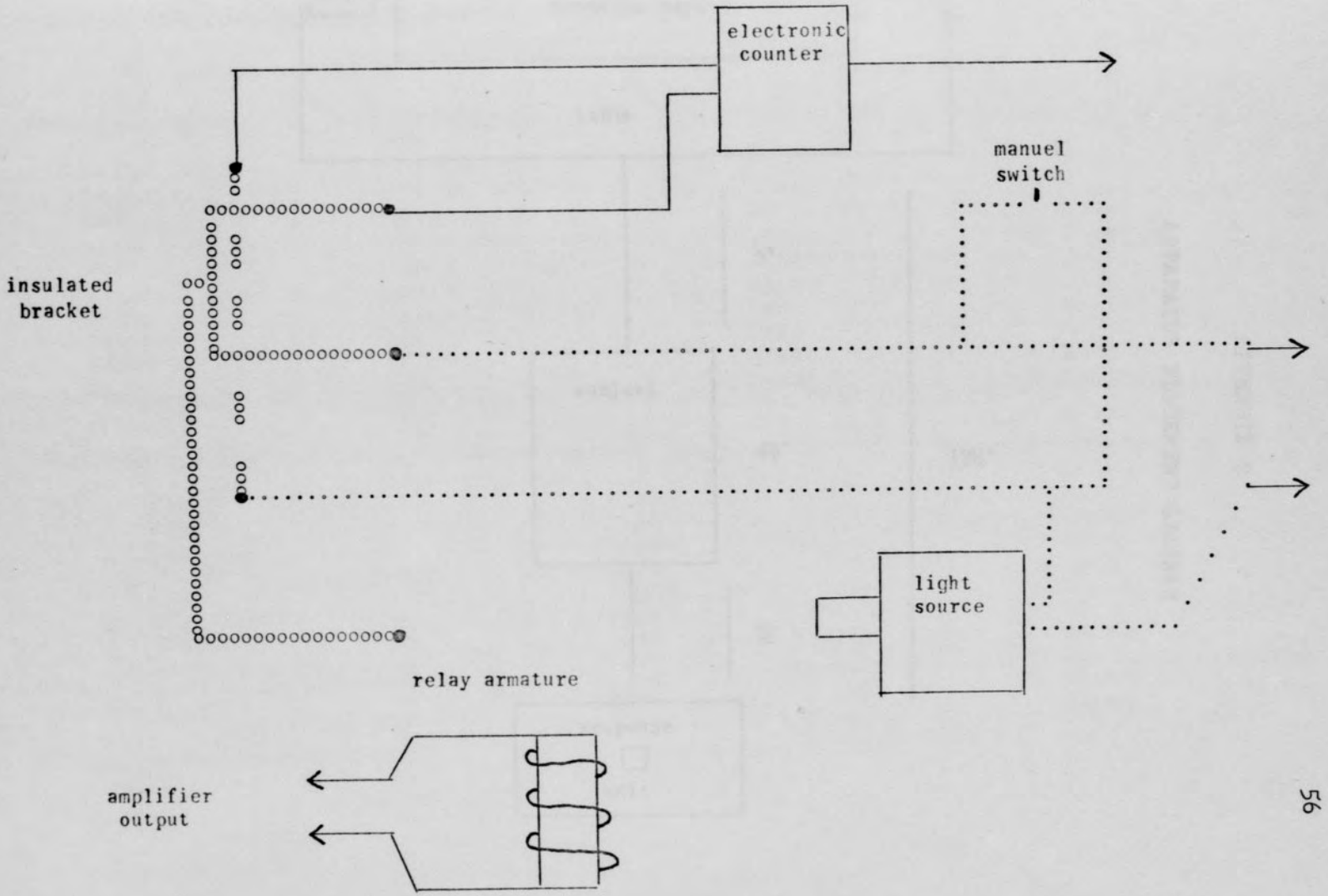
BASE SCORES

1.
2.
3.

EXPERIMENTAL SCORES

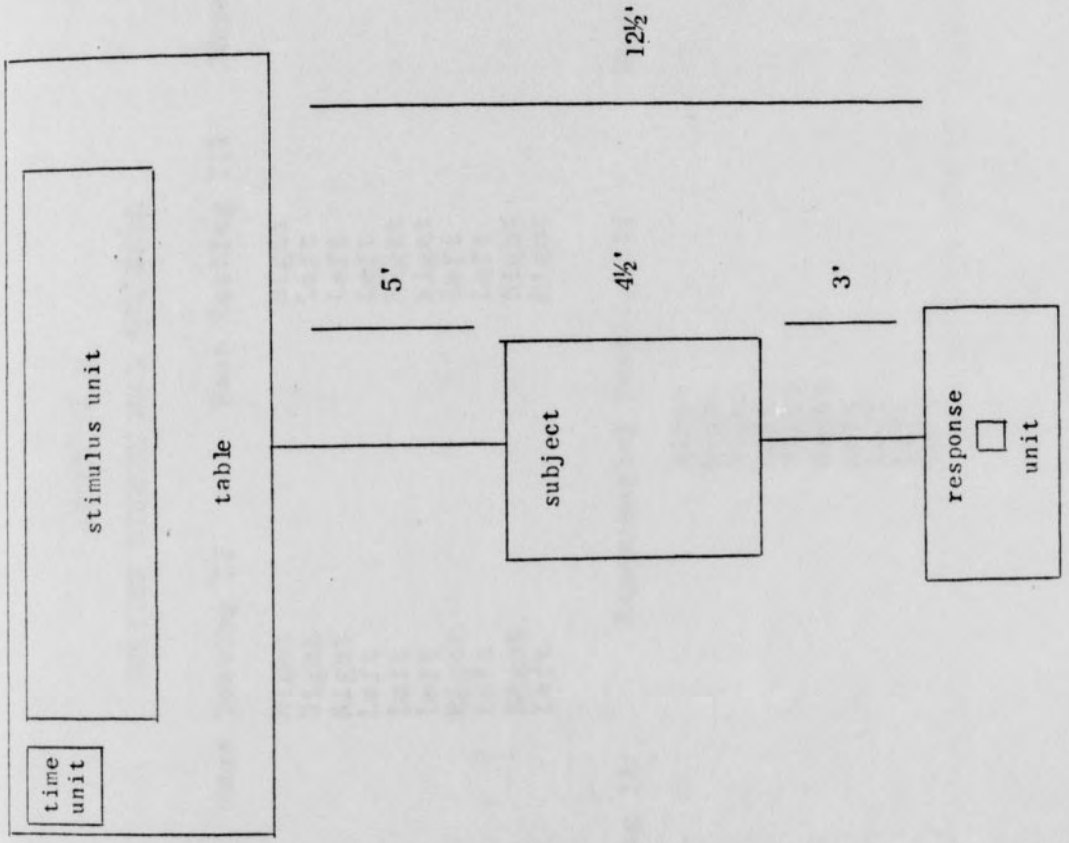
1.
2.
3.
4.

APPENDIX B--APPARATUS ELECTRICAL CIRCUIT DRAWING



APPENDIX C

APPARATUS PLACEMENT DIAGRAM



APPENDIX D

TESTING DIRECTIONAL SEQUENCE

Base Testing I	Base Testing II	Base Testing III	Experimental Testing I
Left	Right	Right	Right
Left	Right	Left	Right
Left	Right	Left	Right
Left	Left	Left	Right
Left	Left	Right	Left
Right	Left	Right	Left
Right	Right	Left	Right
Right	Left	Left	Left
Right	Right	Right	Left
Right	Left	Right	Left

Experimental Testing II	Experimental Testing III	Experimental Testing IV
Right	Right	Left
Right	Right	Left
Left	Right	Right
Right	Left	Left
Left	Right	Right
Right	Right	Left
Right	Left	Right
Left	Left	Left
Left	Left	Right
Left	Left	Right