THE EFFECTS OF LEARNING

ON SELECTED PHYSIOLOGICAL REACTIONS

by

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A Thesis Submitted to
the Faculty of the Graduate School at
The Woman's College of the University of North Carolina
in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Greensboro
June, 1962

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ACKNOWLEDGEMENT

The writer wishes to express her sincere gratitude and appreciation to Dr. Celeste Ulrich for her interest, advice, and wisdom in guiding this study.

Appreciation is also extended to the twenty-seven students of The Woman's College who gave so freely of their energy and physiological reactions.

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CHAPTER I

INTRODUCTION

One of the modern unifying theories of mankind is the one concerned with the effects of stress on the organism; a theory which makes an attempt at unifying the physical, psychological, and social concepts of man; a theory which presents interest to both the scientist and the layman. If it will ever be possible to adjust human living and thereby control the amount of stress experienced by an individual, great strides could be taken in the maintenance of health. Stress itself is not only necessary, but it is even desirable. It is a part of life, a natural by-product of all activities and should not be avoided. The meaning and direction of life is found by letting stressful situations be of use in constructive, meaningful patterns of behavior and activity. Selye[14:277] has said, "It is only in the heat of stress that individuality can be perfectly molded."

There are a variety of causes of stress and these stressors may be physical, social, and psychological in nature. Research has established that activity or exertion serves as a physical stressor[9]. It has also been established that psychic stressors are among the most important and serious of stressors[14]. In many situations, it would be impossible to separate the physical from the psychic, since both are involved in producing a stress situation. Studies have shown that physical stressors[73] and psychic stressors [22,34,37,62,67,68,72,73] applied separately or simultaneously have caused homeostatic upsets in various systems of the body.

Recently, concern has been expressed about learning to live with stress and just how the organism adjusts to decrease the reactions after repeated exposure to a stressor. Gross[4] has stated that the process of adaptation that the body goes through with repeated exposure to a stressor is an educational phenomenon in every learning process. She goes on to say that learning is permanent adaptation.

Upon exposure to a physical activity containing supposed elements of unfamiliarity which could be capable of eliciting emotional behavior, homeostatic upsets in the physiological reactions of the body might be expected. Since Selye has contended it is possible for the body to adapt to such a situation, and Gross has stated that learning is permanent adaptation, then if through continued exposure to the activity, learning does take place, it might be assumed that permanent adaptation has occurred. With permanent adaptation, physiological upset from the homeostatic level should be at a minimum.

This study is concerned with ascertaining if any of these relationships might exist. The effects of learning three different motor activities on the physiological reactions of the body were measured by recording these reactions before and after exposure to each of the activities judged to be a stressor and both before and after instruction in the activities assumed to be stressors.

CHAPTER II

STATEMENT OF THE PROBLEM

The purpose of this study was to compare the effects of motor learning on selected physiological reactions of the body as a result of a stressor. Of the many possible physiological reactions affected, respiration rate, respiration amplitude, pulse rate, galvanic skin response, and blood pressure were selected to be used in this study.

Three activities were selected as those to be learned, based upon the basic motor ability elements of balance, coordination, and accuracy. Both physical and psychic stressors were considered, since any activity would involve physical exertion and the introduction of a new activity could be a psychic stressor.

The study compared the physiological reactions at base level, after the initial exposure to each activity, and after the final exposure to each activity following instruction periods. Performance scores were also compared using the initial score, final score, and average performance score of each activity.

A secondary purpose of this study was to determine relationships existing between the physiological reactions under each of the three conditions and to determine various relationships with the performance scores.

CHAPTER III

REVIEW OF LITERATURE

While the concept of stress in the science of medicine is not new, the stress theory as a frame of reference in scientific investigation has only been functional since 1936. In relation to other discoveries and theories, rapid strides have been made in developing the stress concept. Gross[4:22] has quoted the British Medical Journal as stating, "No theory in living memory has stimulated research to such an extent." But in relation to modern technological and scientific developments, only the surface of the stress theory has been scratched.

Hans Selye, the creator of the stress concept, has defined stress as simply, "the rate of wear and tear within the body"[14:55]. Any agent or condition that upsets the homeostatic level of the body systems causes stress and is termed a stressor. These causes may be physical or psychological in nature, but whatever the cause, the organic results are similar. For stress is a nonspecific reaction and the body does not differentiate between the causes. When the organism is affected by a stressor a specific syndrome occurs, which Selye[13,14,15,61] has called the General Adaptation Syndrome.

This General Adaptation Syndrome consists of all of the changes that the body undergoes in response to a stressor. It is the body's adaptative mechanism. The General Adaptation Syndrome can be divided into three stages, all of which need not occur in response to a stressor: 1) the alarm reaction, characterized by marked acute organic manifestations which alert the body to the stressor, 2) the stage of resistance, when the body is adapting to the stressor and resisting the external force, and 3) the stage of exhaustion which may result in death if the body has not been able to resist and/or adapt to the stressor.

Stress can only be measured in terms of the physiological reactions that occur as a part of the General Adaptation Syndrome. The intensity of the stressor is a factor in determining the amount of stress produced, but individual adaptation ability has a much greater influence. Morehouse and Miller[9:205] have attributed the different reactions to the same stressful situation by different individuals to "inherited and acquired characteristics". Selye[14] has gone even further with the concept of inherited adaptation energy that is used to adjust to stressful situations. He feels that this is the most fundamental gap in our knowledge about stress. Not a great deal has been revealed about this energy, only that it exists and is used. But such a concept might help to explain the various effects the same situation can have on different people.

During the General Adaptation Syndrome, many physiological adjustments are made by the body in order to adapt to the stressor. The alarm reaction and exhaustion stages are characterized by similar physiological symptoms as a warning to the body. During the stage of resistance, however, the symptoms seem to disappear.

Exposure to stressors is much more common than might be expected; in fact, it is impossible to imagine when one is not exposed to some kind of a stressor (i.e., temperature, excitement, pain, infection, physical exertion, mental work, tension, etc.). By means of some electrical or chemical reaction not yet fully understood, the pituitary gland is stimulated to produce adrenocorticotrophic hormone, which, in turn, stimulates the production of corticoids by the cortex of the adrenal glands. The autonomic nervous system is alerted and sympathetic nervous responses are produced immediately. With the corticoids carried by the blood stream, nervous and emotional reactions occur and through biochemistry every tissue ot the body is affected in some manner.

The greatest amount of work in the stress concept done to date has been the quantitative measures of the symptoms of the syndrome. Endocrine secretion cannot be collected and measured, so the secondary effects are the only measuring device available.

A great deal of work has been done with resultant cardiovascular changes. The sympathetic nervous responses sent out upon stimulation by a stressor cause adrenaline to be produced by the medulla of the adrenal glands, which in turn increases the heart rate[2,4,9,18].

Baker and Taylor[22] explored the possibility that exposure to stress conditions was emotion provoking. Variations in physiological reactions, including an increase in heart rate, seemed to verify their assumption. Harmon and Johnson[34] used several tests of emotional reactivity to investigate the emotional reactions of college athletes, and concluded that the increase in pulse rate was the physiological reaction easiest to detect. Howell[38] used electric shock to induce stress and found a change in pulse rate significantly different as a result of the stressor.

The increased corticoid concentration in the blood influences the blood vessels of the kidneys to produce a renal pressor substance. This is a chemical which affects the walls of blood vessels and its increased secretion raises the blood pressure[14].

Harmon and Johnson[34] found that systolic blood pressure in college athletes increased just preceeding an athletic contest as a result of the emotional disturbance. Johnson[40] compared the effect of emotional build-up on athletes involved in two different types of contests and found almost no reaction in football players compared to considerable reaction in wrestlers. These results were obtained by measuring the increase in blood pressure. Hennis and Ulrich[37] used four variables to measure the effect of psychic stress, one of which was blood pressure. Although all variables showed a significant difference after the application of the stressor, the rise in blood pressure was the only consistent directional change.

Other cardiovascular changes that have been explored as resultants of stress are blood coagulation rate[14,72], a decrease in eosinophil blood cells[4,14,67], and the disintegration of lymphatic cells[4,14].

Cannon[2] included the dilation of the bronchioles as a change brought about by sympathetic nervous responses. This would increase the capacity of oxygen, and as a result, respiration rate and respiration amplitude might be increased. Ulrich and Burke[68] found an increase in both respiration rate and respiration amplitude as a result of motivational stress. Massey[73] reported a significant difference in respiration amplitude after applying both a physical and psychic stressor. Ulrich[67] found as the eosinophil count decreased during adjustment to stress, both respiration rate and pulse rate increased.

According to Mowrer[11], perspiration has been associated with emotional stress for some time. Research in relating emotional behavior and tensions to sweating has been carried on by researchers in psychology with various degrees of success. Kuno, as cited by Mowrer[11], explained the two kinds of sweating, one caused by physical stimuli such as heat and muscular work which increase the body temperature, and the other caused by emotions, mental stress, and sensory stimulation, having no effect whatsoever on the body temperature. Significantly, emotional sweating appears on the hands and feet, and heat regulation sweating occurs on the general body surface.

Several types of measurements have been used with varying degrees of success in understanding the significance of sweating as an emotional response. Davis[30] used palmar prints, before and after exposure to a stressor, as a tool to determine emotional upset. Perhaps the most widely used index of emotional activity with regard to sweating is the electrical resistance of the skin. Freeman and Griffin[32:63] reported that if attention is given to the necessary controls, ". . . palmar resistance may be taken as reliable indices of general excitation level of the neuro-muscular apparatus."

Changes in the electrical properties of the skin are end products of complicated neurological, biological, and chemical processes, under the control of the autonomic nervous system, and not completely understood even today. According to Landis[46], Müller in 1904 reported that variability of electrical skin resistance depended upon factors such as time of day, habits of the subject, nervous or mental state of the subject, and physiological phenomena. These observations have been repeatedly verified.[28,45,54,55]

Conflicting information exists concerning the relationship of the secretion of sweat and electrical skin response. Darrow[29], Richter[55], and Wang and Lu, as cited by Landis[46], have reported that the sweat glands control the electrical response. MacNitt[47], on the other hand, observed that the action of the sweat glands had little influence on the response. Morgan and Steller[10] and Woodworth and Schlosberg[20] have contended that sweating itself is not the cause of the response, but rather a neural or chemical activity in the skin produces the response.

The electrical changes in the resistance of the skin, or galvanic skin response has received a great deal of attention because of the speed and sensitivity of the response to stimulation. According to Block[24:14], the galvanic skin response is ". . . a convenient index of the tensional state, . . . It has no implication, however, for the direction of the response precipitated by the emotion."

Johnson[40] used the galvanic skin response and a word association test to determine that athletes were more reactive in a pre-contest situation. Baker and Taylor[22] measured skin resistance, skin temperature, and pulse rate before and after exposure to a stress condition. They found the resistance decreased, the temperature increased, and the pulse rate increased. Harmon and Johnson[34] investigated the emotional reactions of college athletes before and after a game situation by measuring galvanic skin response, pulse rate, and blood pressure. Preceding the contest, the emotional disturbance was of an intensity to measure a significant difference in all of the variables. The galvanic skin response proved to be the best single indicator.

Skubic[62] used the galvanic skin response to record emotional reactions of boys to baseball. Little League, Middle League, and physical education class situations were used for both league players and non-players. The results derived from 206 boys showed that a response occurred in all three situations, but those in the league play elicited no more response from competition than from physical education.

Other physiological reactions that make up the General Adaptation

Syndrome include the release of more sugar into the blood by the liver, an increase in metabolic rate brought about by the thyroid gland, and the inhibition of inflammation by the connective tissue cells.

Exercise is considered to be a physical stressor, one that can be of value to an individual. According to Morehouse and Miller[9:206], "... it has been suggested that exercise may act to stabilize the homeostatic balance by providing a means of offsetting the physiological consequences of emotional stress." On the other hand, both emotional and physical stress together may result in a maximal stimulus for the stress mechanism.

Any instrument that indicates or records physiological reactions simultaneously is called a "polygraph", meaning many pictures. The polygraph, also called a deceptograph or more commonly a lie detector, has been in use since 1906, when it was invented for medical examinations[39]. It is now widely used not for detecting lies, but for detecting emotions that cause physiological disturbance of the body functions. Each emotional reaction causes the same physiological changes, so that no interpretation can be made as to the actual emotional cause[25]. Many of these functions can be observed without a machine but not as accurately.

This study is concerned with the circulatory and respiratory systems, and the sweating process of the excretory system. Within the circulatory system, two measurements are of concern, pulse rate and blood pressure. The American Heart Association accepts a range of 50-100 beats per minute as normal[6]. In a well person, this rate is affected by age, body position, time of day, food intake, emotions, and physical activity[6,7,9]. The actual acceleration may start before exercise begins, due to the anticipation of the activity[9]. According to Morehouse and Miller[9], Morehouse and Tuttle[50], Tuttle and Salit[65], Elbel[31], and Karpovich[6], the increase in pulse rate during exercise is dependent upon the type and strenuousness of the exercise. Karpovich goes on to say the rate will begin to return to its normal resting rate approximately ten seconds after exercise ceases. The time necessary for a complete return is dependent upon the intensity of the exercise and the condition of the individual. Occasionally this could fall below the pre-exercise level, especially if some psychological factor influenced the pre-exercise rate[6].

Systolic blood pressure is the pressure the blood exerts on the walls of the arteries during ventricular systole. Normal resting systolic blood pressure ranges from 110 to 135 millimeters of mercury.

Muscular activity causes a rise in systolic blood pressure, the amount of the increase dependent upon the amount of exercise and individual differences[6,7,9]. Very moderate exercise may not influence blood pressure, but as exercise increases, so does systolic pressure. The blood pressure falls rapidly immediately after the cessation of exercise and returns to normal more quickly than does the pulse rate[6,9].

In the respiratory system, both respiration rate and respiration amplitude are of concern. Normal resting rate and amplitude of breathing are dependent upon a variety of factors, one of which is exercise. During exercise, respiration supplies oxygen to the muscles for metabolism and helps keep the acid-base balance in the blood[6,9]. In moderate exercise, a steady respiration state is reached in three to five minutes, as frequency, volume, and depth increase. The time required to return to the pre-exercise level is determined by the severity and duration of the exercise and the physical condition of the subject, although the rate of breathing returns to normal more slowly than the depth of breathing[9].

Sweat glands are unevenly distributed throughout the surface of the body, with a greater concentration in the palms of the hands and the soles of the feet[18]. The autonomic nervous system controls the secretion of sweat on the basis of internal body temperature. When sweat evaporates from the surface of the skin, it produces a cooling effect on the body. Sweating compensates for increased heat production during exercise[9], and therefore increases as the amount of exercise increases. A total of 3.5 liters of sweat may be produced by the body of an adult male in one hour under severe conditions. The extracellular fluid is the source of the sweat, which contains both water and sodium and chloride electrolytes[5].

LEARNING

At the present time, there is no general theory of learning that is accepted by all psychologists. Since everyone looks at the problem from different sides and with the results of diverse experimentation, different factors are emphasized[19]. The area of learning is under continual experimentation, for there are few phenomena that have so much practical application.

Wordworth and Marquis[19] stated that when the individual responds to a stimulus, the activity of the response is what is learned because of the strengthening of muscle fibers and probably the brain neurons involved. They said further that this learning is more than merely strengthening.

> A learned act is something new added to the individual's repertory. Typically at least learning consists in doing something new, provided this something new is retained by the individual and reappears in his later activities.[497]

In a later edition, Woodworth and Schlosberg[20] are reluctant to define learning because the concept is too broad to be specific, as it is not one specific kind of activity.

Most psychologists will, however, agree on the factors that influence learning. Basically, Woodworth and Marquis[19] have stated these factors in the simple terminology of 1) observation of the stimulus and results of the activity, 2) two or more similar stimulus patterns, 3) exercise and repetition of the activity, 4) spacing of the repetitions, 5) reinforcement of selected activities to be learned, and 6) motivation to accomplish the task.

Those in the field of physical education are interested in how learning takes place, especially as applied to motor learning. Ruch[12] has defined motor learning as any learning that involves primarily the use of the muscles of the body, and in so doing, builds new muscular coordinations in response to some stimulus. Physical educators have been quite aware of Thorndike's Law of Exercise[16], and thus, many facets of practice sessions have undergone research.

Knapp and Dixon[42] have stated that practice is one of the keys in learning motor skills and then have listed seven variables that seem to influence the benefits derived from practice: 1) duration of practice sessions, 2) length of rest period between sessions, 3) practice method, 4) speed of movement during practice, 5) characteristics of the learner, 6) activity of the learner during the time between practice sessions, and 7) complexity of the skill.

Harmon and Oxendine[36] studied the various lengths of practice periods in mirror tracing. They concluded that in the early stages of learning, a greater length in the practice period improved performance. Knapp and Dixon[42] compared the results of two different lengths and distributions of practices in the learning to juggle. They found that short, daily sessions produced better results than longer alternate day sessions.

Harmon and Miller[35] used college women who were beginners in billiards to study the effects of spacing the practice sessions. It was concluded that massed practice in the onset was desirable, with the intervals between practice sessions lengthened progressively. Young[71] did a comparison of two-day-a-week versus four-day-a-week practice sessions in college archery and badminton classes. She found that more rapid learning occurred in archery with the four-day-a-week plan and in badminton with the two-day-a-week plan.

Massey[48] used three different groups practicing at different intervals on a stabilimeter. After a five week program, each group having a different number of sessions, she concluded a three-day-a-week plan was superior to a five-day-a-week plan and a summation plan on the basis of progress achieved in a minimum number of sessions. Scott[58], in working with the learning rates of 154 beginning swimmers, concluded that insufficient evidence was available to compare two, three, and four-day-a-week practice sessions.

As far as practice methods are concerned, the whole and part idea has created considerable interest. Knapp and Dixon[43] compared the two methods in beginning juggling and concluded the subjects using the whole method attained the criterion quicker, but that a combination of the whole and part methods would probably result in more effective learning.

Vandell, Davis, and Clugston[69] studied the effect of mental practice on acquiring motor skill. They definitely noted that improvement can occur as a result of mental practice, and in the experiment, such mental practice was as effective as physical practice. Twining[66] used three groups of college men, with no practice sessions, physical practice sessions, and mental practice sessions. Both groups with the practice sessions improved significantly, although those with physical practice improved three times as much as those using mental practice. Clark[26] used 144 subjects, half utilizing physical practice and half mental practice, in learning the Pacific Coast one hand foul shot. Both groups improved significantly, but the physical practice seemed to be slightly more effective.

Solley[64] investigated the hypothesis that if speed is retarded until reasonable accuracy is achieved, and then speed is increased gradually, both speed and accuracy are developed to the ultimate. After six weeks of practice, and three different programs of emphasis on speed and accuracy, it was found that about the same degree of both speed and accuracy was attained. He suggested as a result of this study, that if speed is the predominate factor, speed should be emphasized from the beginning. If both speed and accuracy are required, both should be emphasized throughout.

Kulcinski[44] found a positive relationship between intelligence of the subject and the degree of learning fundamental motor skills in fifth and sixth graders. Scott[58] found that motor ability is one factor in determining learning rate. Snell, as cited by Soares[74], studied the rates of learning in low motor ability college women and found that they did better in badminton, volleyball, and bowling than in archery, basketball, and tennis.

Phillips and Summers[52], in developing bowling norms and learning curves, found that the most noticeable change is the initial rise at the lowest skill levels. Scott[58] concluded the swimming study with, "Individual learning rates differ markedly." In 1931, McGeoch[49:732] summed this up when she said, "... roughly comparable procedures and practice conditions on different motor problems have given contradictory results... There is no inherently superior method." This appears to be true today.

> The learning variables are extremely numerous. The task itself may vary in kind, in length of lesson, in difficulty of problem. The number of learning trials, the massing or spacing of the trials, the age and organic and emotional state of the learner,

> the instruction and possible assistance and guidance given him, and still other factors may be systematically varied.(20:532)

Since 1920 when reported experimentation in the area of motor ability began, many studies have been concerned with defining the term, devising tests for such general ability, and measuring various elements that make up the general term.

Perrin[51] in 1921 attempted to analyze motor ability using both simple and complex motor tests, intelligence tests, university academic grades, and character estimates. He concluded that any kind of movement involves many factors, definitely of a 'specialized' nature. This concept was reinforced in 1923 by Garfiel[33] when she reported that motor ability represents a group of abilities, either independent or different from mental abilities.

In 1932, Alden, Horton, and Caldwell[21] catalogued motor ability into five aspects; speed of voluntary movement, accuracy of voluntary movement, control of involuntary movement, strength, and motor adaptability.

Motor ability is defined by Bovard, Cozens, and Hagman as "... the level to which one has developed his innate capacity to learn motor skills."(1:144)

There have been many attempts to construct test batteries in order to classify students before teaching motor skills. These are short tests, based upon a large number of varied tests to measure the various abilities. Scott[57] devised a test to evaluate a college freshman's ability for classification in physical education activities upon entry into college. She felt that knowing the status of the students' abilities was a factor essential to the most effective teaching. Two batteries were recommended, either a dash, basketball throw, and Sargent jump, or an obstacle race, basketball throw, and Sargent jump. After additional study, Scott[59] replaced the Sargent jump with the broad jump and devised a formula to convert the raw scores from the items in the battery to a general motor ability score. A T-scale was also developed to give additional meaning to the general motor ability score.

In addition to test batteries used to measure general motor ability, endeavors have been made to evaluate the qualities of this ability directly. Larson and Yocum[8:184] list the basic elements of the fundamental skills involved in motor ability as"... muscular strength, endurance, speed, accuracy, balance, rhythm, body coordination, sensory motor coordination, shiftiness, steadiness, and agility." Bovard, Cozens, and Hagman[1] classify all of these into two groups: capacity and endurance, and co-ordination. In this study, the elements of balance, sensory motor coordination, and accuracy were used.

Balance can be defined as one's ability to control his body neuromuscularly. There are two types of balance to be measured: static balance, or equilibrium while maintaining the body in one position, and dynamic balance, or equilibrium maintained while continuously changing positions of the body.

Alden, Horton, and Caldwell[21] used four balance beams, one-half inch wide and ten feet long placed end to end. The subject walked heel-to-toe as far as possible. The score was determined by the number of feet the subject was able to walk.

A rather inclusive balance study was done by Bass[23] in 1939. The Stepping Stone Test of dynamic balance involved leaping through a course of ten circles and remaining in each for five seconds. Scores were determinted by both time needed to complete the course and any resulting errors. This test was found to have a reliability of .952.

Seashore[60] reported the development of a beam walking test and the results obtained by Whitney, Dain, and Hanson. Nine oak beams equal in length and distance from the floor, but varying in width from four inches to one-fourth of an inch were the apparatus. The subjects walked ten steps on each beam, beginning with the widest, until falling off of the same beam twice. The reliability varied from .75 to .86, depending upon the number of trials given.

In 1952, Reynolds[53] devised an apparatus containing a teeter board on which the subject balanced. This test was used by Slater-Hammel[63] as a discriminating measure of ability.

Body coordination and sensory motor coordination are general terms applied to the integration of movements of different kinds into a single pattern. Body coordination tests, such as a dodge run or direction change test, also involve agility, balance, and speed. In order to refine the measurement of coordination, this study was concerned with sensory motor coordination, and hand-eye coordination in particular.

Garfiel[33] used a three hole test as a measure of this fine motor coordination. The three holes were tapped by a metal stylus one hundred times, moving clockwise around a triangular arrangement. Together with a tapping test, this test had a correlation of .79.

In selecting a battery of tests for fitness, Collins and Howe[27] used a target similar to the three hole test. Instead of the metal stylus, a fencing foil was used and the subject had to lunge one hundred times at metal discs in the vertices of the triangle. The lunging alternated with touching an overhead target. Scores were obtained by dividing the number of hits by the amount of time needed to complete the lunges.

Martus[70] used four tests to investigate coordination as an element of motor ability, utilizing both large and small muscle activities. The Miles Pursuit Pendulum Test was used as a measure of fine coordination and had a reliability of .503. In 1932, Morse[70] derived six coordination tests, three whose multiple correlation with coordination criterion was .836. One of the three mentioned was a target test, consisting of throwing twelve darts at a forty-inch target with little or no body movement so that only arm and hand coordination was involved.

Accuracy can be defined as the ability of one to control voluntary movement toward an object, either at a distance or in contact with the body. Throwing or kicking at a target are most often used as measures of accuracy.

In 1910, Whipple[17] published a precision test using a target of blanks containing ten crosses and a stylus to aim at the crosses. The subject contacted the crosses in time to a metronome. In Garfiel's study[33], an arm target test was reported consisting of three concentric circles at which small rubber balls were thrown. Lensch[70] devised a general motor ability test for college women and included an accuracy throw. A regulation archery target served as the target. Ten baseballs were thrown from a distance of twenty feet. The reliability of this test was found to be .741.

In light of the literature reviewed, it may be that the exposure and performance of an unfamiliar physical activity can produce stress, with both physical and psychic causes. A condition of stress has been discovered by an increase in pulse rate, a rise in systolic blood pressure, an increase in both respiration rate and respiration amplitude, and the increase of electrical resistance of the skin. Learning of an activity can be ascertained by continued better performance by the individual involved.

CHAPTER IV

PROCEDURE

In order to determine the effects of learning on an individual's physiological reactions, respiration rate, respiration amplitude, galvanic skin response, and pulse rate were recorded simultaneously by the Stoelting Deceptograph. This was done six times under normal conditions to obtain a homeostatic level which would represent a base rate, once immediately after the presentation and trial of each of three unfamiliar activities, and once three weeks later immediately after the completion of each of the three previously presented activities. During the two weeks time between the initial and final testing sessions, five group instructional practice sessions were held to familiarize the subjects with the three activities.

SELECTION OF SUBJECTS

The subjects for this study were selected from the freshmen and sophomores enrolled at The Woman's College, University of North Carolina. In order that all of the subjects be of relatively the same motor ability, only those girls whose Scott Motor Ability Test T-scores were between 45 and 55 were considered. Fifty-two girls were selected at random from the 629 qualifying. Any girl that had had instruction in either fencing or lacrosse during her college years was then eliminated. The subjects ranged in age from seventeen to nineteen years and all had been approved for physical education activity classes by the college physician. Of the thirty-one that began the study, twenty-seven completed it. There was no reason to think this group deviated in any way from the normal college population except in the aforementioned criteria.

SELECTION OF A MEASURING INSTRUMENT

In order simultaneously to record graphically the physiological responses to the experimental situations, a Deceptograph #22500 manufactured by the C. H. Stoelting Company of Chicago was used. This instrument records respiration, galvanic skin response, pulse rate, and blood pressure changes. Because it was desirable that all of these effects be quantitatively measured, the blood pressure changes were not considered in the study.

The respiration section of the deceptograph records the frequency and amplitude of inhalation and exhalation. A rubber corrugated pneumograph is attached to the subject across the chest in a slightly stretched position. A metal bellows receives the impulses from the pneumograph and transmits them to a five inch pen which records the responses on a moving roll of chart paper.

The sphymographic section records the relative blood pressure changes and pulse rate. Either a regulation blood pressure cuff on the brachial artery or a wrist cuff on the radial artery may be used. To obtain as sensitive a reading as possible, the wrist cuff was used on the brachial artery. The impulses are transmitted through rubber tubing to a metal bellows and lever system which moves a five inch pen on the moving chart paper.

The galvanic skin response measures the minute electrical variations in the subject's skin at the point of attachment of the electrodes. These variations cause an unbalance in the amplifier which in turn causes the galvanometer to record on the chart paper by means of a seven inch pen. Finger electrodes are attached to nonadjacent fingers in order to avoid shorting of the amplifier.

All three pens record simultaneously on a chart, moving at the rate of six inches per minute. Vertical lines indicate five second intervals and horizontal lines serve as guide lines when interpreting the chart. A sample of the chart paper may be found in the Appendix. A more detailed explanation of the operation of the deceptograph may be found in the instruction manual which accompanies the machine.

SELECTION OF ACTIVITIES

According to Larson and Yocum[8], fundamental abilities are those underlying the skills necessary for performance in various sports. Three of these fundamentals are balance, sensory motor coordination, and accuracy. The primary factor used in selecting activities that represent these three abilities was that some degree of learning the activity was possible and the learning had to be capable of being measured numerically. Therefore, simple pass-fail tests of these abilities were not enough.

The balance activity consisted of a series of eighteen stunts, descriptions of which may be found in the Appendix, done continuously on a balance beam twenty-four feet long, two inches wide, and nine inches off of the floor. The beam was marked off in two foot sections, and each stunt was done in a different section as the subject progressed along the beam. This meant that the first stunt was done in the first section, the fifth stunt in the fifth section, and so forth. The subject walked from one section to the next as she progressed. Completion of each stunt was judged by the experimenter and the activity was considered completed when the subject touched a foot to the floor. The number of the two foot section where the subject lost her balance and stepped down was considered to be her score for the activity.

Of all sensory motor coordinations, hand-eye seemed to be one of greatest significance for use. The test used by Collins and Howe[27] to measure hand-eye coordination offered possibilities, but seemed to require a great deal of endurance, an element which did not fit into the framework of this study. Modifications were made in the Collins and Howe test by this experimenter so that hand-eye coordination was as nearly as possible the only ability under consideration.

Metal discs four inches in diameter were mounted in the vertices of an equilateral triangular target with thirty-six inch sides. The subject was instructed to stand far enough from the target so that she was able to touch the discs with a fencing foil only by means of a lunge. The left foot of right handed subjects was then braced against the floor and the middle of the target was hung shoulder high. A metal disc twelve inches in diameter was hung four feet above the subject's right shoulder (right handed subject) so that upon completion of a lunge, she would resume a normal standing position, lift the foil, and touch the overhanging target. The actual activity consisted of lunging twenty-one times at one of the three discs, alternating around the triangle beginning with the lower left disc. After each lunge, the subject resumed a normal standing position and touched the overhanging target. The foil and discs on the triangular target were electrically wired so that when contact was made by the foil, the circuit was completed and a buzzer sounded. The number of initial touches and length of time needed to complete the twenty-one lunges were both tallied by the experimenter. Scores were tabulated by dividing the number of hits by the amount of time in seconds.

The accuracy activity consisted of throwing with a lacrosse stick a regulation lacrosse ball twenty-five feet to a target hanging on the wall four and a half feet from the floor. This target consisted of three concentric circles with radii of six, twelve, and eighteen inches. Each of the circles was surfaced with a different material so that it was easy to determine which circle had been hit. Points were awarded on a five, three, of the beam, she was again seated in the chair and the deceptograph attached to her. The blood pressure cuff was pumped up immediately and the galvanic skin response adjustments were left at the same sensitivity level as before the activity. Approximately twenty-five seconds elapsed from the time the subject stepped off of the beam until her physiological reactions were being recorded. The reactions were again recorded for a two minute period. Descriptions of the stunts done on the balance beam may be found in the Appendix.

During introduction to the fencing activity, the subject was given the foil to hold, and shown how to lunge forward so that her left foot could be placed in proper position in relation to the target. Instructions were given for the subject to lunge at the discs in the vertices of the triangular target, alternating with the overhanging target until told to stop. The activity was begun by the experimenter saying "Ready -GO!". Upon completion of the twenty-one lunges, the subject placed the foil down and returned to the chair. Approximately twenty seconds elapsed until the physiological reactions were recorded.

The lacrosse throw was performed in the gymnasium. The throw was demonstrated by the experimenter three times and then tried three times by the subject. Only very brief instructions were given.

> Put one hand on the collar of the stick and the other on the butt end of the stick. (Demonstrate). Hold the stick horizontal to the floor over the shoulder of the top hand. Now throw the ball from the stick like this. (Demonstrate).

After the three trials, the subject threw ten balls at the target. Upon one basis and ten trials were administered to each subject. Total scores were obtained by dividing the total number of points by the total number of hits.

COLLECTION OF DATA

The collection of data in this study was divided into three parts. During the first week, all of the subjects reported individually to the experimenter for three twenty minute periods. These periods were scheduled at the convenience of the subject, but whenever possible on three different days, at approximately the same time each day. After obtaining all vital background information, the subject was seated in an armed chair facing away from the deceptograph in a room as free from distraction as was possible. The pneumograph was fastened around the subject's chest, the blood pressure wrist cuff was wrapped around the right arm, just above the elbow, and the finger electrodes were fastened on two nonadjacent fingers of the left hand. The subject was told:

> Sit as quietly as possible when the machine is on since any little movement will be recorded. Get comfortable now, with both feet flat on the floor. The arm cuff will be pumped up shortly and will remain inflated for two minutes. It may be a little uncomfortable near the end of this period, but it will have no lasting effect.

The galvanic skin sensitivity control was set at approximately twenty-three for the majority of the subjects. Occasionally a setting below twenty-three was used. The manufacturer recommends that the lowest setting possible be used. Such a setting controls the amplitude of the galvanic skin response pen. The balancing control which matches the skin resistance of the subject was then adjusted so that the galvanic skin response pen was centered on the chart roll.

After closing the pneumo vent, the pneumograph pen moved across the top of the chart roll in a rhythmic pattern as the subject breathed. Movement of the chart roll was then started so that any adjustment could have been made before pumping up the blood pressure cuff. With the rubber hand pump attached to the machine, the cuff was inflated to the maximum oscillation of the needle in the sphygmomanometer dial. This point is supposed to be ten to fifteen millimeters of mercury below the systolic blood pressure level. The snap clamp on the pump was closed and the cardio pen put in the record position. If the cuff pressure was correct, the dicrotic notch appeared midway in the pen's arc on the moving chart. The three pens recorded uninterrupted for two minutes.

The subject was then disconnected from the instrument and introduced to the activity she was to perform that day. The order in which the activities were presented was balance beam, fencing, and lacrosse throwing.

One trial at walking the length of the beam for adjustment purposes was allowed. No demonstrations, only verbal instructions, concerning the eighteen stunts to be performed were given the subject. Then the subject mounted the beam and followed the instructions of the experimenter as the activity progressed. As soon as the subject stepped off completion of this activity, the subject walked back into the examination room and approximately forty-five seconds after the performance of the activity her physiological reactions were recorded.

The next two weeks of the study were devoted to teaching the three activities to all participants in five instruction periods of a minimum of one hour each. Several possible times were offered to the subjects for each lesson and each girl chose the one most convenient for her. After some instruction in each of the three activities during a lesson, time was allotted for practice, and then each subject was tested in each activity by the experimenter. These scores were recorded and an average performance score was obtained from the five scores in that activity. The outline of material presented during the instruction periods may be found in the Appendix.

The last phase of the study was similar to the first, in that each girl reported individually to the experimenter for three twenty minute periods. These test periods were scheduled at the convenience of the subject, but on three different days at approximately the same time of day as the first three testing periods. The procedure during each of these periods was identical to the first three periods. In addition, the subject's systolic and diastolic blood pressures were taken before getting any readings on the deceptograph. After the initial two minutes of recording, the subject performed the activity for the day, had her score recorded, and had the deceptograph re-attached to her. Then, before getting the post activity readings, the systolic blood pressure was taken. The deceptograph then recorded the physiological reactions for two minutes. When the systolic blood pressure was taken after the activity, the deceptograph recordings were delayed approximately fifteen to twenty seconds.

CHAPTER V

PRESENTATION OF DATA

The purpose of this study was to compare the physiological reactions of respiration rate, respiration amplitude, galvanic skin response, and pulse rate before and after the learning of three motor activities of a sample of college women. The physiological reactions were recorded simultaneously by a deceptograph. Six readings of these reactions were taken to determine a homeostatic level which would represent a base rate. The reactions were recorded immediately after the introduction and performance of each of the three motor activities (to be referred to as initial test) and immediately after the performance of each of the three motor activities after five instruction periods (final test). Systolic blood pressure was taken three times to determine a homeostatic level which would represent a base rate, and after the final test of each of the three motor activities.

STATISTICAL ANALYSIS

Differences between Means

Since this study was designed to compare the differences that might exist between physiological reactions recorded at base rate, after initial testing, and after final testing, Fisher's "t" formula[3] was used to compute the significance of difference between means and between the means of difference scores.

It was decided that the five per cent level or below was the level at which the statistics would be considered significant.

The test for significance of difference between correlated means was applied to the base level and initial test mean scores for each of the physiological reactions in each of the three activities. A summary of these computations will be found in Table I.

In the balance activity, a difference in pulse rate was found to be statistically significant at the one per cent level of confidence, with the base level being the larger. Similarly, in the coordination activity, a difference in both the respiration rate and respiration amplitude was found to be statistically significant at the one per cent level of confidence. A difference in galvanic skin response was also found to be statistically significant at the two per cent level of confidence. In all of these instances the mean of the initial test was found to be the larger. In the accuracy activity, a difference in respiration rate, respiration amplitude, and galvanic skin response was found to be statistically significant at the one per cent level of confidence. In all instances the mean of the initial test was found to be the larger.

The test for significance of difference between correlated means was applied to the base level and final test mean score for each of the

TABLE I

SIGNIFICANCE OF DIFFERENCE BETWEEN PHYSIOLOGICAL REACTIONS AT BASE LEVEL AND INITIAL TEST

	Mean of Difference	σ of Difference	"t"
BALANCE			
Respiration Rate	.6411	2.0272	1.6128
Respiration Amplitude	.9622	2.9706	1.6518
Pulse Rate	3.6859	6.6144	2.8416***
Galvanic Skin Response	6.2159	39.0737	.8112
COORDINATION			
Respiration Rate	2.0425	2.4068	4.3273***
Respiration Amplitude	5.8622	4.6225	6.4668***
Pulse Rate	.9066	10.3886	.4450
Galvanic Skin Response	23.3270	43.2662	2.7491**
ACCURACY			
Respiration Rate	1.8592	2.0584	4.4256***
Respiration Amplitude	4.8160	3.7765	6.2480***
Pulse Rate	1.6118	8.6349	.9518
Galvanic Skin Response	26.1048	44.1099	3.0177***

** Indicates statistical significance at the 2 per cent level of confidence.
***Indicates statistical significance at the 1 per cent level of confidence.

physiological reactions in each of the three activities. A summary of these computations will be found in Table II.

In the balance activity, a difference in both respiration rate and blood pressure was found to be statistically significant at the one per cent level of confidence. A difference in respiration amplitude was found to be statistically significant at the two per cent level of confidence. Similarly, a difference in galvanic skin response was found to be statistically significant at the five per cent level of confidence. In all instances the mean of the final test was found to be the larger.

In the coordination activity, a difference in respiration rate, respiration amplitude, galvanic skin response, and blood pressure was found to be statistically significant at the one per cent level of confidence. In all instances the mean of the final test was greater.

Similarly, in the accuracy activity, a difference in respiration rate, respiration amplitude, galvanic skin response, and blood pressure was found to be statistically significant at the one per cent level of confidence. In all instances the mean of the final test was larger.

The test of significance of difference between correlated means was applied to the initial test and final test mean scores for each of the physiological reactions in each of the three activities. A summary of these computations will be found in Table III.

In the balance activity, a difference in respiration rate was found to be statistically significant at the two per cent level of confidence,

TABLE II

SIGNIFICANCE OF DIFFERENCE BETWEEN
PHYSIOLOGICAL REACTIONS AT BASE LEVEL AND FINAL TEST

	Mean of Difference	σ of Difference	"t"
BALANCE			
Respiration Rate	1.9374	1.2293	8.0390***
Respiration Amplitude	1.9548	3.6205	2.7532**
Pulse Rate	1.4266	8.6190	.8439
Galvanic Skin Response	23.3270	50.8749	2.3380*
Blood Pressure	10.9600	12.8046	4.1932***
COORDINATION			
Respiration Rate	1.7707	1.0811	8.3523***
Respiration Amplitude	4.3807	3.3729	6.6233***
Pulse Rate	2.7229	7.6991	1.8033
Galvanic Skin Response	31.1048	41.2901	3.8412***
Blood Pressure	15.9259	9.6107	8.4496***
ACCURACY			
Respiration Rate	1.5855	1.6811	4.8103***
Respiration Amplitude	2.1214	3.3731	3.2069***
Pulse Rate	2.6474	7.4920	1.8018
Galvanic Skin Response	25.5862	44.3203	2.9436***
Blood Pressure	19.1851	8.7859	11.1347***

* Indicates statistical significance at the 5 per cent level of confidence.
** Indicates statistical significance at the 2 per cent level of confidence.
***Indicates statistical significance at the 1 per cent level of confidence.

TABLE III

SIGNIFICANCE OF DIFFERENCE BETWEEN
PHYSIOLOGICAL REACTIONS AT INITIAL TEST AND FINAL TEST

	Mean of Difference	σ of Difference	"t"
BALANCE			
Respiration Rate	1.2962	2.4047	2.7485**
Respiration Amplitude	.9925	4.0371	1.2536
Pulse Rate	2.2592	9.7737	1.1786
Galvanic Skin Response	17.8518	54.1739	1.6803
COORDINATION			
Respiration Rate	.0555	3.0937	.0914
Respiration Amplitude	1.4814	5.0726	1.4891
Pulse Rate	3.6296	13.7090	1.3500
Galvanic Skin Response	7.4074	43.8902	.8606
ACCURACY			
Respiration Rate	.4000	2.5417	.7710
Respiration Amplitude	2.7120	4.7726	2.7841**
Pulse Rate	4.3333	10.8800	2.0308
Galvanic Skin Response	.2222	52.1326	.0217

** Indicates statistical significance at the 2 per cent level of confidence.

with the mean of the final test being the larger. In the accuracy activity, a difference in respiration amplitude was found to be statistically significant at the two per cent level of confidence, with the mean of the initial test being the larger.

The test for significance of difference between correlated means was applied to the initial test and final test mean scores of each of the three motor activities. A summary of these computations will be found in Table IV.

A difference in both the balance activity scores and the coordination activity scores was found to be statistically significant at the one per cent level of confidence. In both instances the mean of the final test was found to be the larger.

The test for significance of difference between correlated means was applied to the average performance and final test mean scores of each of the three motor activities. The summary of the computations is found in Table IV. In the coordination activity, a difference was found to be statistically significant at the one per cent level of confidence, with the final mean score being the larger.

Because this study was concerned with the relationship between individual differences of the subjects, three <u>difference</u> scores were computed. The first difference score, noted as D_1, was found by subtracting the initial test scores from the base level scores; the second difference score, noted as D_2, was found by subtracting the final test scores from

TABLE IV

SIGNIFICANCE OF DIFFERENCE BETWEEN
INITIAL, FINAL, AND AVERAGE MOTOR ACTIVITY SCORES

	Initial Mean	Final Mean	"t"	Average Mean	Final Mean	"t"
Balance	2.9259	5.2592	3.1264***	4.7685	5.2592	.1909
Coordination	.3421	.5697	11.9736***	.5069	.5697	4.7862***
Accuracy	1.5753	2.1033	1.9864	2.2209	2.4366	.4747

***Indicates statistical significance at the 1 per cent level of confidence.

the initial test scores; and the third difference score, noted as D_3, was found by subtracting the final test scores from the base level scores. These secondary measurements, labeled the difference scores, were used further to clarify statistical relationships that might exist.

The test for significance of difference between correlated means was applied to D_1 and D_2 for each of the physiological reactions in the three motor activities. A summary of these computations will be found in Table V.

In the balance activity, a difference in respiration rate, respiration amplitude, and galvanic skin response was found to be statistically significant at the one per cent level of confidence, with the mean of D_2 being the larger in all instances. Similarly, a difference in pulse rate was found to be statistically significant also at the one per cent level of confidence, but with the mean of D_1 being the larger.

In the coordination activity, a difference in respiration rate, respiration amplitude, and galvanic skin response was found to be statistically significant at the one per cent level of confidence, with the mean of D_1 in all instances being the larger. A difference in pulse rate also was found to be statistically significant at the one per cent level of confidence, with the mean of D_2 being the larger.

In the accuracy activity, a difference in respiration rate, respiration amplitude, and galvanic skin response was found to be statistically significant at the one per cent level of confidence, with the mean of

TABLE V

SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF DIFFERENCE SCORES FOR PHYSIOLOGICAL REACTIONS AT BASE LEVEL, INITIAL TEST, AND FINAL TEST

Physiological Reactions	$D_1 - D_2$ "t"	$D_1 - D_3$ "t"	$D_2 - D_3$ "t"
BALANCE			
Respiration Rate	8.0552***	6.2091***	6.9780***
Respiration Amplitude	5.8368***	5.6309***	6.0944***
Pulse Rate	6.0339***	5.6718***	8.6554***
Galvanic Skin Response	7.6388***	6.3316***	7.0197***
COORDINATION			
Respiration Rate	6.5040***	5.2497***	5.0998***
Respiration Amplitude	6.4694***	6.7710***	7.8907***
Pulse Rate	6.2388***	5.3472***	8.3749***
Galvanic Skin Response	8.8328***	4.2670***	9.8036***
ACCURACY			
Respiration Rate	6.0348***	7.6982***	8.4566***
Respiration Amplitude	5.3813***	5.7425***	6.8032***
Pulse Rate	5.6911***	6.8064***	6.0726***
Galvanic Skin Response	9.0042***	5.1386***	8.5178***

***Indicates statistical significance at the 1 per cent level of confidence.

D_1 the larger. Similarly, a difference in pulse rate also was found to be statistically significant at the one per cent level of confidence with the mean of D_2 being the larger.

The test for significance of difference between correlated means was applied to D_1 and D_3 for each of the physiological reactions in the three motor activities. A summary of these computations will be found in Table V.

In the balance activity, a difference in respiration rate, respiration amplitude, and galvanic skin response was found to be statistically significant at the one per cent level of confidence, with the mean of D_3 being the larger in all instances. A difference in pulse rate was found to be statistically significant at the one per cent level of confidence with the mean of D_1 the larger.

In the coordination activity, a difference in respiration rate and respiration amplitude was found to be statistically significant at the one per cent level of confidence with the mean of D_1 being the larger. Similarly, a difference in pulse rate and galvanic skin response was found to be statistically significant at the one per cent level of confidence with the mean of D_3 being the larger.

In this respect in the accuracy activity, a difference in respiration rate, pulse rate, and galvanic skin response was found to be statistically significant at the one per cent level of confidence with the mean of D_3 being the larger in all instances. A difference in respiration amplitude was found also to be statistically significant at the one per cent level of confidence with the mean of D_1 the larger.

The test for significance of difference between correlated means was applied to D_2 and D_3 for each of the physiological reactions in the three motor activities. In both the balance and coordination activities, a difference in respiration rate, respiration amplitude, and galvanic skin response was found to be statistically significant at the one per cent level of confidence. In all instances, the mean of D_3 was found to be the larger. Similarly, in both the balance and coordination activities, a difference in pulse rate was found to be statistically significant at the one per cent level of confidence with the mean of D_2 being the larger.

In the accuracy activity, a difference in respiration rate and galvanic skin response was found to be statistically significant at the one per cent level of confidence with the mean of D_3 the larger. A difference in respiration amplitude and pulse rate was found also to be statistically significant at the one per cent level of confidence with the mean of D_2 the larger. These computations are summarized in Table V.

<u>Correlations</u>

The Pearson Product-Moment Coefficient of Correlation[3] was the statistical procedure used in computing relationships between the various physiological reactions at the base level, initial test, and final test. A summary of these computations will be found in Tables VI, VII, and VIII.

At the base level, a negative relationship, statistically significant at the one per cent level of confidence, was found between the respiration rate and respiration amplitude. A positive relationship, statistically significant at the five per cent level of confidence, was found between the respiration rate and blood pressure.

In the initial test in the balance activity, a negative relationship, statistically significant at the one per cent level of confidence, was found between the respiration rate and respiration amplitude. In the coordination activity, a negative relationship, statistically significant at the five per cent level of confidence, was found between respiration rate and respiration amplitude and a positive relationship, also statistically significant at the five per cent level of confidence, was found between pulse rate and respiration rate. Similarly, in the accuracy activity, a negative relationship, statistically significant at the one per cent level of confidence, was found between respiration rate and respiration amplitude.

In the final test, a negative relationship, statistically significant at the one per cent level of confidence, was found between respiration rate and respiration amplitude in the balance activity. In this respect, a negative relationship, statistically significant at the one per cent level of confidence was found between respiration rate and respiration amplitude, and between blood pressure and galvanic skin response in the coordi-

TABLE VI

CORRELATIONS BETWEEN
PHYSIOLOGICAL REACTIONS AT THE BASE LEVEL

	Blood Pressure	Respiration Amplitude	Pulse Rate	Galvanic Skin Response
Respiration Rate	.4012*	-.6684***	.1669	.2292
Galvanic Skin Response	-.0284	.0907	.1329	
Pulse Rate	.0862	.2347		
Respiration Amplitude	-.1942			

* Indicates statistical significance at the 5 per cent level of confidence.
***Indicates statistical significance at the 1 per cent level of confidence.

TABLE VII

CORRELATIONS BETWEEN
PHYSIOLOGICAL REACTIONS OF THE INITIAL TEST

	Respiration Amplitude	Pulse Rate	Galvanic Skin Response
BALANCE			
Respiration Rate	-.7170***	.0728	.2204
Galvanic Skin Response	-.1028	-.1341	
Pulse Rate	.3487		
COORDINATION			
Respiration Rate	-.4705*	.3835*	.1501
Galvanic Skin Response	-.1861	.0075	
Pulse Rate	.2095		
ACCURACY			
Respiration Rate	-.6218***	.2556	.2141
Galvanic Skin Response	-.2016	.1017	
Pulse Rate	.0955		

* Indicates statistical significance at the 5 per cent level of confidence.
***Indicates statistical significance at the 1 per cent level of confidence.

TABLE VIII

CORRELATIONS BETWEEN
PHYSIOLOGICAL REACTIONS OF THE FINAL TEST

	Blood Pressure	Respiration Amplitude	Pulse Rate	Galvanic Skin Response
BALANCE				
Respiration Rate	.2016	-.5962***	.3319	-.3499
Galvanic Skin Response	-.1193	.0419	-.0695	
Pulse Rate	.2323	-.2385		
Respiration Amplitude	.3375			
COORDINATION				
Respiration Rate	.2388	-.5517***	.1404	-.0753
Galvanic Skin Response	-.5439***	-.2885	-.0794	
Pulse Rate	-.2526	.1218		
Respiration Amplitude	-.0803			
ACCURACY				
Respiration Rate	.4492*	-.5716***	.3043	-.2026
Galvanic Skin Response	-.1700	-.1203	-.3448	
Pulse Rate	.2549	.5210***		
Respiration Amplitude	-.3851*			

* Indicates statistical significance at the 5 per cent level of confidence.

***Indicates statistical significance at the 1 per cent level of confidence.

nation activity. Similarly in this respect, a negative relationship, statistically significant at the one per cent level of confidence, was found between respiration rate and respiration amplitude in the accuracy activity. Also in the accuracy activity, a negative relationship, statistically significant at the five per cent level of confidence, was found between respiration amplitude and blood pressure. A positive relationship, statistically significant at the one per cent level of confidence, was found between pulse rate and respiration amplitude; a positive relationship, statistically significant at the five per cent level of confidence, was found between blood pressure and respiration rate.

The Pearson Product-Moment Coefficient of Correlation was the statistical procedure used in computing the relationships between the average performance scores of the three motor activities. No statistical significance was found, since the correlation between the balance and coordination activities was .2789; between the balance and accuracy activities -.0182; and between the coordination and accuracy activities .1235.

The Pearson Product-Moment Coefficient of Correlation was the statistical procedure used in computing the relationships between the physiological reactions of D_3 and the average performance scores of the three motor activities. The data for this compilation is summarized in Table IX. No statistical significance was found.

The Pearson Product-Moment Coefficient of Correlation was the

TABLE IX

CORRELATIONS BETWEEN AVERAGE MOTOR ACTIVITY SCORES AND PHYSIOLOGICAL REACTIONS OF D_3 AND MOTOR ABILITY

	Balance	Coordination	Accuracy
D_3 Physiological Reactions			
Respiration Rate	.3529	-.1280	.0790
Respiration Amplitude	-.2593	-.0982	-.0946
Pulse Rate	-.1400	-.1653	.1035
Galvanic Skin Response	-.2378	-.0601	.2545
Blood Pressure	-.3126	.1488	.1686
Motor Ability	-.1419	-.3344	.1324

statistical procedure used in computing relationships between motor ability T scores and the average performance scores of the three motor activities. The data for this compilation is summarized in Table IX. No statistical significance was found.

CHAPTER VI

ANALYSIS OF DATA

The effects of the learning of three motor activities on the physiological reactions of respiration rate, respiration amplitude, galvanic skin response, pulse rate, and blood pressure in a sample of college women were determined by drawing comparisons and computing relationships between the measurements recorded before and after the learning of the activities.

The test for significance of difference between means was applied to measurements of the physiological reactions recorded at base level, after initial exposure to each activity, and after the final exposure to each activity. Similar statistical treatment was applied to the difference scores of the physiological reactions. Measurements of performance in each of the three activities were also treated statistically to determine the significance of difference of the means of the initial, average, and final test scores.

Measurements were treated statistically to determine relationships evident by correlation between the physiological reactions at the base level, after the initial exposure, and after the final exposure to each of the three activities. Measurements were also treated statistically to determine relationships between the average performance scores of the three activities and the difference scores obtained by using the physiological reactions at the base level and after the final exposure to each of the three activities. Measurements were treated statistically to determine relationships between the average performance activity scores and motor ability scores, and the average performance activity scores with one another.

Balance

The first motor activity used was one involving balance. In comparing the physiological reactions at the base level and those following the initial exposure to the activity, only the difference in pulse rate was statistically significant. Since the pulse rate was higher at the base level, this would indicate that the introduction of the new activity did not elicit a physiological reaction. In fact, it might be that the physical activity tended to equalize the psychic stress thought to be induced by the new activity.

In comparing the physiological reactions at the base level to those following the final exposure to the activity, respiration rate, respiration amplitude, galvanic skin response, and blood pressure increased significantly. It would appear that this might be due to the physical exertion experienced during the activity or there is the possibility that the psychic stress induced by performing the activity caused the changes. Whatever the cause, it was not of sufficient intensity to change the pulse rate significantly.

When the physiological reactions of the initial exposure and final exposure were compared, only respiration rate was significantly different. The increase in respiration rate might be attributed to the increased physical exertion of the final test. It is possible that this increased physical exertion tended to equalize any psychic reactions that might have resulted from the initial exposure and therefore, not change the other physiological reactions significantly.

When difference scores were compared, it was found that the difference between the initial exposure and final exposure was significantly greater in respiration rate, respiration amplitude, and galvanic skin response than the difference between the base level and the initial exposure. This may be due to a greater increase in either physical exertion or in psychic stress from the initial and final as compared to the base and initial. The difference score in pulse rate was also significant, with the base-initial difference greater than the initial-final difference.

The difference scores resulting from the base level and final exposure scores were significantly greater in respiration rate, respiration amplitude, and galvanic skin response when compared with the difference scores resulting from the base level and initial exposure. This would indicate that additional physical and/or psychic factors were present at the final testing to cause greater homeostatic upset as compared to the initial testing. Pulse rate also showed a significant difference, with the difference scores of base-initial greater than base-final. Pulse rate, then decreased as exposure to the activity progressed.

Similarly, the difference scores resulting from the base level and final testing were significantly greater in respiration rate, respiration amplitude, and galvanic skin response when compared to the difference scores obtained from the initial and final testings. In view of this, it appears that the homeostatic level was upset more with the final testing than the homeostatic change between the initial and final testings. The pulse rate also showed a significant difference with the initial-final difference score higher than the base-final difference score. It would appear that the pulse rate changed more from the initial test to the final test than it changed from the base level to the final test.

The significance indicated by these difference scores is in accordance with Selye's theory[13,14] that the homeostatic level is upset by the introduction of a stressor, but the direction of the change is variable.

There was a significant difference in the initial and final performance scores for the balance activity, with the scores of the final test being the larger. This would indicate that since the subjects performed significantly better on the final test, learning of the balance activity did take place. However, when the performance scores of the final testing were compared to the average performance scores, no statistical difference was found. It would appear then that the learning began with the first practice session and continued gradually through the final test.

After both the initial and final testings of the balance activity, a statistically significant negative correlation was found between respiration rate and respiration amplitude. This may be explained by the fact that as breathing depth increased, breathing rate decreased. The reverse was also true.

In determining various relationships with the average performance scores for the balance activity, these scores were correlated with the physiological difference scores resulting from the base level and final test, with no statistical significance evident. It would appear from this that the learning of the balance activity had no relationship to the physiological changes resulting from the base-final test differences. No significant statistical relationship was found between the average balance activity scores and motor ability scores, indicating that within this sample of college women, motor ability did not relate to the learning of the activity.

Coordination

The second motor activity to be used was one involving hand-eye coordination. In comparing the physiological reactions at the base level and those following the initial exposure to the coordination activity, respiration rate, respiration amplitude, and galvanic skin response were significantly larger following the initial test. It would appear that either the physical exertion or psychic stressor caused these reactions, but the intensity was not of sufficient strength to change the pulse rate.

When the physiological reactions of the base level were compared to those following the final exposure to the activity, respiration rate, respiration amplitude, galvanic skin response, and blood pressure changed significantly. These reactions increased after the final exposure, probably as a result of either or both the physical exertion of performing or the psychic stress elicited by the testing. In either case, the stressor was not strong enough to change the pulse rate.

In comparing the physiological reactions after the initial exposure to those following the final exposure, no statistical significant difference was evident. It would appear then, that since there was no physiological difference, both of these situations were of nearly equal intensity as sources of stress. Therefore, the instructional practice sessions and any learning that took place in this activity did not tend to reduce the adaptive physiological reactions of the body.

When the difference scores of physiological reactions in the coordination activity were compared, it was found that the difference between the base level and the initial exposure was significantly greater in respiration rate, respiration amplitude, and galvanic skin response than the difference between the initial exposure and the final exposure. It may reasonably be assumed that the initial introduction of the activity caused a greater change in the homeostatic level of these reactions than did continued application of the stressor. The difference scores for pulse rate from the initial and final exposure were significantly greater than difference scores from the base level and initial exposure. It would appear that the pulse rate was changed more by the continued exposure from the initial to the final test than by the initial introduction of the activity.

The difference scores resulting from the base level and initial exposure were significantly greater in respiration rate and respiration amplitude than the difference scores of the base level and final exposure. This would indicate that the initial exposure caused a greater homeostatic upset than did the final exposure, and would imply the cause to be of a psychic nature. The difference scores resulting from the base level and final exposure were significantly greater in pulse rate and galvanic skin response than the difference scores of the base level and initial test. Since greater physical exertion occurred at the final testing as compared to the initial testing, it would appear that this exertion tended to more than equalize the psychic stressor of the initial exposure.

The difference scores resulting from the base level and final exposure were significantly greater in respiration rate, respiration amplitude, and galvanic skin response when compared to the difference scores of the initial and final exposures. It would appear that the final exposure was enough of a stressor, either physical or psychic in nature, to cause greater physiological reaction than occurred between the initial and final exposures to the coordination activity. The difference scores resulting from the initial and final exposures were significantly greater in pulse rate than the difference scores of the base level and final exposure. This indicates that the pulse rate changed more from the initial testing to the final testing than it did from the base level to the final testing.

The performance scores from the initial and final testings showed a significant difference, with the scores of the final test the larger. This better performance on the final test would indicate that learning of the coordination activity had taken place. When the final test scores were compared to the average performance scores, the final scores were significantly larger. This would indicate better performance on the final test than during the instruction periods.

In both the initial and final testings of the coordination activity, a statistical significant negative correlation was found between respiration rate and respiration amplitude. It seems as breathing rate increased, the depth of breathing decreased, and vice versa. This can be attributed to the fact that both the rate and depth of breathing influence the amount of oxygen consumed by the body.

In the initial testing, a statistically significant positive correlation was found between respiration rate and pulse rate, indicating that as one increased, so did the other. A statistical significant negative correlation was found between blood pressure and galvanic skin response in the final testing, indicating that as one increased, the other decreased.

In order to determine various relationships with the average performance scores for the coordination activity, these scores were correlated with the physiological difference scores determined from the base level and final test. No statistical significance resulted, inferring that as learning in the activity increased, no significant physiological changes occurred. When the average performance scores were correlated with motor ability scores, no statistical significance resulted, signifying that within this study, motor ability did not influence the learning of the co-ordination activity.

Accuracy

The third motor activity to be used in this study involved accuracy. In comparing the physiological reactions at the base level and after the initial exposure, respiration rate, respiration amplitude, and galvanic skin response increased significantly following the initial exposure. Pulse rate did not change significantly. It would appear that the exposure to the activity was enough of a stressor, either physical or psychic, to elicit a physiological reaction, but not of sufficient intensity as a stressor to upset the homeostatic level of the pulse rate.

In comparing the reactions at the base level with those following the final exposure to the accuracy activity, respiration rate, respiration amplitude, galvanic skin response, and blood pressure increased significantly. Since the increase appeared after the final exposure, it appears the stressor was present, whether physical or psychic in nature, but not of sufficient intensity to increase the pulse rate.

When the physiological reactions following the initial and final exposures were compared, only respiration amplitude changed significantly in favor of the initial test. It would seem that physiologically, the body reacted much the same way after both testing periods, except that the initial test caused significantly deeper breathing. This could have been due to either physical or psychic causes.

In considering difference scores, it was found that the differences between the physiological reactions at the base level and the initial exposure were significantly greater in respiration rate, respiration amplitude, and galvanic skin response than the difference between the initial and final exposures. This would indicate that the physiological changes upon the initial exposure caused a greater homeostatic upset than did the continued application of the stressor. The difference between the initial and final exposures was significantly larger in pulse rate than was the difference between base level and initial exposure. It would appear that the pulse rate was affected more by the continued exposure than by the initial exposure.

The difference scores resulting from the base level and final exposure were significantly larger in respiration rate, pulse rate, and galvanic skin response than the difference scores between the base level and initial exposure. This seems to indicate that the final exposure caused a greater homeostatic upset than did the initial exposure. The difference between the base level and the initial exposure was significantly larger in respiration amplitude than the difference between the base level and the final test. It would appear that the greater depth in breathing occurring after the initial exposure was of psychic origin.

The difference scores resulting from the base level and the final exposure were significantly greater in respiration rate and galvanic skin response than the difference scores between the initial and final exposures. Thus, the final exposure to the activity caused a greater physiological reaction than did the continued exposure as measured by the above reactions. The difference scores resulting from the initial and final exposures were significantly larger in respiration amplitude and pulse rate than the difference scores between the base level and the final test. It would appear that the continued exposure to the accuracy activity caused greater homeostatic upset than did the final test in the reactions mentioned.

In comparing the performance between the initial and final tests, no significant difference was found. This would seem to indicate that no significant learning took place between the two tests. In comparing the final performance scores to the average performance scores of the accuracy activity, no significant difference was found. This would further indicate that little learning took place in this activity during the study.

After both the initial and final testings of the accuracy activity, a statistically significant negative correlation was found between respiration rate and respiration amplitude. This may be explained by the fact that as breathing depth decreased, breathing rate increased. The reverse would also be true. Following the final exposure, a statistically significant negative correlation was also found between respiration amplitude and blood pressure. This would mean that as the blood pressure rose, the depth of breathing decreased. The statistically significant positive correlation between blood pressure and respiration rate found during this testing would verify that as respiration rate and blood pressure increased together, respiration amplitude decreased. A statistically significant positive correlation was also found between respiration amplitude and pulse rate. As respiration amplitude decreased during this testing, so did the pulse rate.

To determine various relationships with the average performance scores of the accuracy activity, these scores were correlated with the physiological difference scores resulting from the base level and final test, with no statistical significance evident. This seems to indicate that the average performance had no relationship to the physiological changes resulting from the base-final differences. No statistical significance was found when the average performance scores were correlated with the motor ability scores. This would seem to indicate that motor ability was not a factor in performance of the accuracy activity in this study.

Additional relationships of interest to this study were the correlation of the physiological reactions at the base level. A statistical significant negative relationship was found between respiration rate and respiration amplitude. Thus, in all of the relationships investigated under all conditions, this negative correlation has existed between respiration rate and respiration amplitude. A statistical significant positive relationship was found between blood pressure and respiration rate. It appears, then, that these are inclined to be somewhat related. Correlations were also done among the three activities used in the study, with no statistical significance found when the average performance scores were used. On the basis of this, it would seem logical that the learning of the three activities had no relationship with one another.

It is evident that physiological reactions did change possibly as a result of the activities presented, following both the initial and final exposure to the performance of the activities. Learning of the balance and coordination activities did take place, as shown by an increase in the performance scores between the initial and final testings. Since no significant difference in performance scores in the accuracy activity was found, it may be assumed that no learning took place.

CHAPTER VII

SUMMARY AND CONCLUSIONS

This study was concerned with the effect the learning of three motor activities has on the physiological reactions resulting from exposure to the activities. The motor activities involved were concerned with balance, coordination, and accuracy. The physiological reactions recorded were respiration rate, respiration amplitude, pulse rate, galvanic skin response, and systolic blood pressure.

A stratified random sampling of twenty-seven freshmen and sophomore students from The Woman's College, University of North Carolina were selected as subjects for the study. A Stoelting Deceptograph was used to simultaneously record the physiological reactions of respiration rate, respiration amplitude, pulse rate, and galvanic skin response upon six occasions to determine a homeostatic level which would represent a base rate. The deceptograph was also used to record the physiological reactions after the initial performance and final performance of each of the three activities. Between these two testing sessions, five group instructional practice sessions were conducted to provide an opportunity for the subjects to learn the activities. Performance scores were recorded for each of the three activities at the initial and final exposures to the activities, and at each of the practice sessions so that an average performance score could be obtained.

Measurements were treated statistically to determine the significance of difference of each of the physiological reactions at base rate, after the initial exposure, and after the final exposure to each of the three activities. Similar statistical treatment was applied to the difference scores of the physiological reactions.

Measurements were treated statistically to determine relationships between the physiological reactions at the base level, after the initial exposure, and after the final exposure to each of the three activities. Statistical relationships were determined between the average performance scores of the three activities and the difference scores obtained by using the physiological reactions at the base level and after the final exposure to each of the three activities. Similar statistical treatment was applied to the average performance scores and motor ability scores, and the average performance scores with one another.

FINDINGS

Balance

1. In comparing physiological reactions at the base level to those following the initial exposure to the balance activity, only pulse rate changed significantly, decreasing after the initial exposure.

2. When the physiological reactions at the base level were compared to those following the final exposure to the balance activity, res-

piration rate, respiration amplitude, galvanic skin response, and blood pressure increased significantly after the final exposure.

3. Only respiration rate changed significantly when comparing the physiological reactions after the initial and final exposures, with the increase occurring after the final exposure.

4. When comparing the base-initial difference scores to the initial-final difference scores, all of the physiological reactions changed significantly. Respiration rate, respiration amplitude, and galvanic skin response differences were greater in the initial-final scores, while the pulse rate differences of the base-initial scores were greater.

5. All physiological reactions changed significantly when comparing the base-final differences to the base-initial differences. Respiration rate, respiration amplitude, and galvanic skin response differences were larger in the base-final, while the pulse rate differences of the base-initial were larger.

6. In comparing the base-final difference scores to the initial-final difference scores, all physiological reactions changed significantly. Respiration rate, respiration amplitude, and galvanic skin response difference scores were higher in the base-final, and the difference scores of pulse rate were greater in the initial-final.

7. The performance scores of the final exposure to the balance activity were significantly larger than those of the initial exposure, but of no significant difference when compared to the average performance

scores.

8. Respiration rate and respiration amplitude had a negative statistical relationship after both the initial and final testings. No other statistical relationships were significant among the physiological reactions at the initial and final testings.

9. No significant statistical relationships were found between the average performance scores and the physiological difference scores of base-final, and between the average performance scores and motor ability scores.

Coordination

1. In comparing physiological reactions at the base level to those following the initial exposure to the coordination activity, respiration rate, respiration amplitude, and galvanic skin response were significantly larger following the initial exposure.

2. When the physiological reactions at the base level were compared to those following the final exposure to the coordination activity, respiration rate, respiration amplitude, galvanic skin response, and blood pressure increased significantly after the final exposure.

3. No statistical difference proved to be significant in comparing the physiological reactions after the initial and final exposures to the activity.

4. When comparing the base-initial difference scores to the

initial-final difference scores, all of the physiological reactions changed significantly. Respiration rate, respiration amplitude, and galvanic skin response differences were greater in the base-initial scores, while the pulse rate differences of the initial-final scores were greater.

5. All physiological reactions changed significantly when comparing the base-initial differences to the base-final differences. Respiration rate and respiration amplitude differences were larger in the base-initial, while the pulse rate and galvanic skin response differences of the base-final were larger.

6. In comparing the base-final difference scores to the initial-final difference scores, all the physiological reactions changed significantly. Respiration rate, respiration amplitude, and galvanic skin response difference scores were higher in the base-final, and the difference scores of pulse rate were greater in the initial-final.

7. The performance scores of the final exposure to the coordination activity were significantly larger than those of the initial exposure, and also significantly larger than the average performance scores.

8. Respiration rate and respiration amplitude had a negative statistical relationship after both the initial and final testings. Respiration rate and pulse rate had a positive statistical relationship in the initial testing. In the final testing, a negative statistical relationship was found between blood pressure and galvanic skin response.

9. No significant statistical relationships were found between

the average performance scores and the physiological difference scores of base-final, and between the average performance scores and motor ability scores.

Accuracy

1. In comparing physiological reactions at the base level to those following the initial exposure to the accuracy activity, respiration rate, respiration amplitude, and galvanic skin response changed significantly, increasing after the initial exposure.

2. When the physiological reactions at the base level were compared to those following the final exposure to the accuracy activity, respiration rate, respiration amplitude, galvanic skin response, and blood pressure increased significantly after the final exposure.

3. Only respiration amplitude changed significantly when comparing the physiological reactions after the initial and final exposures, with a decrease following the final exposure.

4. When comparing the base-initial difference scores to the initial-final difference scores, all of the physiological reactions changed significantly. Respiration rate, respiration amplitude, and galvanic skin response differences were greater in the base-initial scores, while the pulse rate differences of the initial-final scores were greater.

5. All physiological reactions changed significantly when comparing the base-final differences to the base-initial differences. Respira-

tion rate, pulse rate, and galvanic skin response differences were larger in the base-final, while respiration amplitude differences of the base-initial were larger.

6. In comparing the base-final difference scores to the initial-final difference scores, all physiological reactions changed significantly. Respiration rate and galvanic skin response difference scores were higher in the base-final, and the difference scores of respiration amplitude and pulse rate were greater in the initial-final.

7. No statistical significance was found between the initial and final performance scores, or between the average performance scores and the final scores.

8. Respiration rate and respiration amplitude had a negative statistical relationship after both the initial and final testings. In the final testing, a negative statistical relationship was found between respiration amplitude and blood pressure, and a positive statistical relationship between respiration amplitude and pulse rate.

9. No significant statistical relationships were found between the average performance scores and the physiological difference scores of base-final, and between the average performance scores and motor ability scores.

10. A statistical significant negative relationship was found to exist between respiration rate and respiration amplitude at the base level, and a significant positive relationship between blood pressure

and respiration rate.

11. No statistical significant relationships were found between the average performance scores of the three activities.

CONCLUSIONS

In view of the fact that it is difficult to separate the psychic from the physical in viewing stressors, that both of these kinds of stressors cause homeostatic upset in various systems of the body, and that there are differences in individual reactions to the same situation or activity; any such stimuli presented to a group would cause homeostatic upset in some of the individuals within the group. Selye[14] has expressed the belief that continued exposure to the same stressor will result in adaptation by the body or, if the stressor is of extreme intensity and no adaptation takes place, death will result.

The results of this study have shown that homeostatic upset did occur in the circulatory system, respiratory system and sweating process of the excretory system upon exposure to and performance of an unfamiliar activity. This upset might be attributed to either physical or psychic phenomena. The direction of this upset was not always constant.

After instruction and practice in each of the three activities, homeostatic upset continued to occur, even though learning appeared to have taken place in the balance and coordination activities.

The experimenter attributes this continued upset to one or all of the major limitations of the study:

1) The recording instrument, the Stoelting Deceptograph, is very complex and appears strange to one unfamiliar with its use. It is entirely possible that the use of this instrument in itself was a psychic stressor and thereby did not give a true recording of the homeostatic level, especially in pulse rate and blood pressure. The advantages of simultaneously recording graphically all of the reactions was at the onset greater than any preconceived disadvantages.

2) Taking part in this study was purely voluntary by those selected as subjects. It is entirely possible that an attitude of indifference was assumed by the subjects in their performance of the activities or in their attempt to learn the activities. The experimenter tried throughout the study to avoid the development of this attitude at all times.

3) The activities chosen for use in this study may not have been of sufficient intensity to cause homeostatic upset as the result of a psychic or physical stressor. A great deal of physical exertion was not required to perform the activities, but since some physical exertion was required, it may be the upset recorded was purely physical and not psychic in nature.

It is with these limitations in mind that the experimenter wishes to recommend that further research be conducted with activities requiring a minimum of physical exertion to ascertain any upset caused purely by psychic means and change that might occur as a result of learning. It is also recommended that if the deceptograph is used in a like manner to record physiological reactions for this type of study, the subjects be completely familiarized with the performance and use of the instrument before the actual study is undertaken.

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APPENDIX

BALANCE ACTIVITY

The stunts done on the balance beam were as follows:

1. Walk forward three steps.
2. Turn 1/4 turn to either side and walk sideways 3 steps.
3. Turn another 1/4 turn so that facing in opposite direction from starting position, walk backwards 3 steps.
4. Turn 1/2 turn around so that facing in starting direction.
5. Bend down, touch beam with hands, take 2 steps forward walking on hands and feet. Resume standing position.
6. Touch one knee to the beam; touch other knee to the beam.
7. Stand on one leg (either), touch sole of raised leg to other knee.
8. Lift left leg sideways to hip level.
9. Lift one leg (either) forward to hip level.
10. Lift right leg sideways to hip level.
11. Hop 3 times on one foot.
12. Lift one leg forward, pivot on other leg away from raised leg 1/2 turn so that facing opposite to starting direction; hold position with raised leg behind.
13. Turn sideways, touch one knee to the beam.
14. Bend down, hold beam with hands, touch forehead to the beam.
15. Duck walk two steps forward.
16. Bend down, hold beam with hands; lift one leg behind body, touch forehead to beam. Resume standing position.
17. Bend down, hold beam with hands, walk forward with hands; with knees straight, inch feet up to hands; walk forward with hands, inch feet up to hands. Resume standing position.

18. Lift one leg forward, bend down on supporting leg until sitting on heel of supporting leg.

OUTLINE OF INSTRUCTIONAL PERIODS

Lesson 1

A. Balance Beam

1. Principles of balance
    a. Center of gravity
    b. Distribution of weight
2. Parts of foot to use
    a. Ball of foot
    b. Instep of foot
3. Methods of walking
    a. Heel to toe
    b. Normal stride
    c. Practice on gymnasium floor lines
4. Demonstrate all stunts

B. Fencing

1. Holding foil
2. Lunge
    a. Demonstrate correct method
    b. Mechanics of knee action
    c. Practice, legs only

C. Lacrosse throw

1. Overarm throw
    a. Mechanics of backswing and follow-through
    b. Practice against wall
2. Holding lacrosse stick
    a. Position of hands
    b. Reason for positioning
3. Throwing, stick in hand
    a. Relation to overarm throw
    b. Practice against wall

D. Supervised practice, with analyzation of performance by experimenter

Lesson 2

A. Balance Beam

1. Review principles of balance
2. Review walking
3. Stunts 1-4
   a. Demonstrate
   b. Hints for execution

B. Fencing

1. Review of lunge, emphasizing push of knees
2. En garde position
   a. Purpose
   b.. Practice, legs only
3. Position of foil arm

C. Lacrosse throw

1. Review holding stick
2. Review throwing with stick as related to overarm throw
3. Position of stick
   a. Before throwing
   b. After throwing

D. Supervised practice with analyzation of performance by experimenter

Lesson 3

A. Balance Beam

1. Review stunts 1-4
2. Stunts 5-8
   a. Demonstrate
   b. Hints for execution

B. Fencing

1. Review lunging from en garde position
2. Aiming
   a. Position of arm and foil before lunging
   b. Position of arm and foil at contact

C. Lacrosse throw

1. Throwing
   a. Initial position
   b. Follow through

2. Arm action
   a. Push top hand
   b. Pull bottom hand

D. Supervised practice with analyzation of performance by experimenter

Lesson 4

A. Balance Beam

1. Review stunts 5-8
2. Stunts 9-12
   a. Demonstrate
   b. Hints for execution

B. Fencing

1. Review lunge, using legs
2. Aiming and lunging at small targets

C. Lacrosse throw

1. Review action of the stick during throw
2. Body action on throw
   a. Push-pull
   b. Weight distribution

D. Supervised practice with analyzation of performance be experimenter

Lesson 5

A. Balance Beam

1. Review stunts 9-12
2. Stunts 13-18
   a. Demonstrate
   b. Hints for execution

B. Fencing

1. Review aiming and lunging
2. Use of free arm
   a. Before lunging
   b. After lunging

C. Lacrosse throw

1. Review action of stick on throw
2. Consistency of throw
    a. Aiming
    b. Factors that influence accuracy

D. Supervised practice with analyzation of performance by experimenter

TABLE X

MEANS AND STANDARD DEVIATIONS
FOR PHYSIOLOGICAL REACTIONS AT BASE LEVEL

	Mean	Standard Deviation
Respiration Rate	16.4815	4.2284
Respiration Amplitude	9.1112	3.0591
Pulse Rate	86.2594	8.0582
Galvanic Skin Response	38.4815	21.4225
Blood Pressure	139.2223	12.3807

TABLE XI

MEANS AND STANDARD DEVIATIONS
FOR PHYSIOLOGICAL REACTIONS AT INITIAL AND FINAL TESTS

	Initial Test		Final Test	
	M	σ	M	σ
BALANCE				
Respiration Rate	17.0740	4.0453	18.4814	4.3151
Respiration Amplitude	10.1852	4.2950	11.1482	4.8360
Pulse Rate	82.6669	9.6381	85.1110	13.3035
Galvanic Skin Response	46.7595	37.4340	64.2590	40.7280
Blood Pressure			151.3000	19.0640
COORDINATION				
Respiration Rate	18.5925	4.5645	18.7778	5.3148
Respiration Amplitude	15.2224	6.1664	13.5926	5.4110
Pulse Rate	87.4447	14.7204	84.0001	11.0151
Galvanic Skin Response	65.0000	40.0000	63.5180	35.9740
Blood Pressure			155.4630	15.1080
ACCURACY				
Respiration Rate	18.0800	4.3993	18.2594	4.9932
Respiration Amplitude	14.2800	5.2424	11.4444	4.8788
Pulse Rate	83.3200	11.0010	89.1112	9.0240
Galvanic Skin Response	66.6000	39.7680	66.8510	36.7220
Blood Pressure			158.4255	15.9885

TABLE XII

MEANS AND STANDARD DEVIATIONS OF
INITIAL, FINAL, AND AVERAGE MOTOR ACTIVITY SCORES

	Initial		Final		Average	
	M	σ	M	σ	M	σ
Balance	2.9259	1.9039	5.2592	3.3733	4.7685	2.5417
Coordination	.3421	.0624	.5697	.0883	.5069	.0648
Accuracy	1.5753	.9841	2.1033	1.1149	2.2209	.5786

TABLE XIII

RAW DATA FOR
PHYSIOLOGICAL REACTIONS AT BASE LEVEL

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Blood Pressure
1	16.67	10.30	78.80	46.83	132
2	18.67	7.40	107.78	34.67	135
3	19.00	6.17	83.30	39.00	137
4	13.33	12.83	89.83	24.67	144
5	16.25	9.17	84.67	21.00	125
6	17.08	7.50	88.00	29.33	176
7	16.17	10.92	79.67	75.67	141
8	23.75	7.33	87.83	83.00	147
9	14.42	7.87	78.83	10.83	137
10	18.17	6.67	89.67	35.83	125
11	10.42	18.42	107.50	68.83	130
12	14.08	7.67	75.50	69.67	136
13	16.92	13.67	92.50	14.33	142
14	14.67	7.67	81.83	9.00	141
15	12.50	10.13	80.33	43.33	124
16	6.75	12.92	91.50	45.50	138
17	12.92	9.17	80.67	43.67	131
18	21.67	5.75	98.50	56.17	139
19	10.25	14.00	76.50	33.00	128
20	16.58	9.75	82.83	41.00	135
21	18.75	6.83	84.00	15.67	161
22	25.67	8.33	93.83	80.33	150
23	15.83	6.25	85.33	14.67	121
24	16.67	9.50	89.83	28.50	138
25	15.75	6.08	77.33	42.00	131
26	16.25	8.50	83.83	19.67	158
27	23.50	4.42	83.33	34.00	156

TABLE XIV

RAW DATA FOR
INITIAL TEST OF BALANCE ACTIVITY

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Activity Score
1	16	4.7	69	3	12
2	17	15.0	116	40	4
3	18	7.5	71	86	3
4	14	13.0	84	50	2
5	17	10.0	80	83	2
6	17	9.5	87	0	4
7	19	8.0	77	96	2
8	23	5.5	79	95	2
9	14	12.5	77	96	3
10	21	5.5	82	5	3
11	10	21.0	96	5	3
12	18	4.0	79	79	3
13	15	14.0	89	16	2
14	19	7.0	88	1	2
15	14	8.0	72	0	2
16	9.5	19.0	89	95	3
17	14	9.0	88	27	2
18	21	5.0	85	38	3
19	8	18.0	66	1	2
20	19	10.0	85	96	2
21	18	8.0	70	69	3
22	24	10.0	83	69	3
23	21	6.5	88	96	1
24	18	10.0	85	0	2
25	16.5	8.0	76	47	3
26	14	13.5	82	20	3
27	25	9.0	91	15	3

TABLE XV

RAW DATA FOR
INITIAL TEST OF COORDINATION ACTIVITY

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Activity Score
1	16	17.5	74	87	.4578
2	19.5	16.0	106	96	.4210
3	22.5	14.0	74	96	.4250
4	16	16.0	99	95	.4042
5	21	7.0	74	94	.4597
6	17	13.5	74	0	.4000
7	18	28.0	75	93	.2222
8	26	14.0	105	0	.3370
9	17	10.5	69	90	.2978
10	17	17.0	81	82	.3478
11	11.5	35.0	119	96	.3269
12	21	9.5	92	2	.3168
13	17	16.5	98	12	.2500
14	13	17.0	83	90	.2970
15	16	8.5	69	47	.3617
16	9	17.0	87	0	.3100
17	14	17.5	70	96	.3518
18	22.5	9.0	108	0	.2393
19	9	18.5	64	0	.3396
20	20.5	10.0	88	93	.3913
21	22.5	11.5	96	103	.2343
22	24.5	18.5	89	96	.3119
23	24	7.0	96	93	.3272
24	20	18.0	115	90	.3703
25	18	15.0	78	53	.2962
26	21	15.0	87	0	.3913
27	24.5	6.5	88	96	.3508

TABLE XVI

RAW DATA FOR
INITIAL TEST OF ACCURACY ACTIVITY

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Activity Score
1	18.5	13.5	83	86	1
2			113	96	3
3	21	14.5	88	48	3
4	14	13.7	90	104	3
5	21	17.8	77	32	2.5
6	19	12.0	78	55	2
7	19.5	14.0	85	33	0
8	25	9.5	113	104	2
9	13.5	14.0	66	9	1
10	19	10.0	84	103	0
11	12	24.0	104	0	1
12	20.5	13.5	72	101	0
13	14.5	17.5	89	24	1.8
14	17	15.8	74	96	1
15	13.5	9.0	68	96	1.4
16	8.5	18.0	80	0	1.0
17	16	11.5	73	0	2.3
18	20	11.5	94	103	3.0
19	8.5	32.0	83	105	1
20	22	9.0	63	108	0
21	21.5	9.0	84	0	3
22	27.5	12.5	98	56	1
23	18	10.0	84	104	1
24	20	11.5	92	103	2
25	19	12.5	79	73	2
26	18	17.5	84	92	1
27			92	44	2.5

TABLE XVII

RAW DATA FOR
FINAL TEST OF BALANCE ACTIVITY

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Blood Pressure	Activity Score
1	16	13.0	68	82		3
2	20	11.5	120	65	148	12
3	21	6.5	99	90	168	8
4	16	15.0	98	102	160	6
5	20	11.0	85	94	156	10
6	18	11.0	96	0	202	4
7	19	12.5	77	1	158	3
8	27	9.5	78	0	158	2
9	15.5	10.5	76	78	156	4
10	19.5	7.5	99	104	130	10
11	17.5	12.5	91	102		2
12	18	6.0	72	50	124	2
13	18	15.0	83	0	162	8
14	17	10.5	87	2	124	2
15	14	6.5	67	38	130	3
16	7.5	17.5	93	105	156	11
17	16	7.0	69	105	138	4
18	24	6.0	106	23	138	5
19	9	29.0	64	96	144	4
20	18	19.0	77	66	152	8
21	19.5	8.0	71	77	142	2
22	27	8.5	96	6	172	13
23	16.5	7.5	89	95	140	4
24	20	11.5	89	9	146	2
25	16.5	9.5	83	105	140	4
26	19	11.5	78	103	158	4
27	25.5	4.5	84	102	168	2

TABLE XVIII

RAW DATA FOR
FINAL TEST OF COORDINATION ACTIVITY

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Blood Pressure	Activity Score
1	18	19.0	81	89	150	.6440
2	20.5	12.0	111	88	140	.6250
3	22	9.5	83	96	148	.6538
4	15.5	17.5	82	0	160	.4358
5	21	11	83	95	152	.7777
6	19	15.5	78	1	206	.5555
7	17	18.5	69	96	158	.5205
8	26	19.5	71	30	162	.4705
9	13	10.5	69	96	152	.7241
10	19	9.5	86	91	142	.5806
11	10	29.0	102	94	138	.6461
12	18.5	7.5	66	96	168	.5428
13	16.5	15.5	79	96	162	.4819
14	17.5	6.0	81	91	148	.5714
15	14	14.5	74	39	138	.5757
16	7	20.5	84	3	162	.5970
17	15.5	13.0	92	96	138	.5135
18	24.5	8.0	99	70	138	.6315
19	11.5	20.0	81	96	140	.5333
20	18.5	19.0	84	60	162	.5757
21	20	11.5	99	96	166	.6363
22	30	7.5	90	66	164	.5633
23	16.5	10.5	93	96	152	.5833
24	24	13.0	79	82	174	.6363
25	15.5	12.5	71	96	138	.3478
26	20	7.0	80	35	172	.4375
27	26	6.0	93	6	158	.5230

TABLE XIX

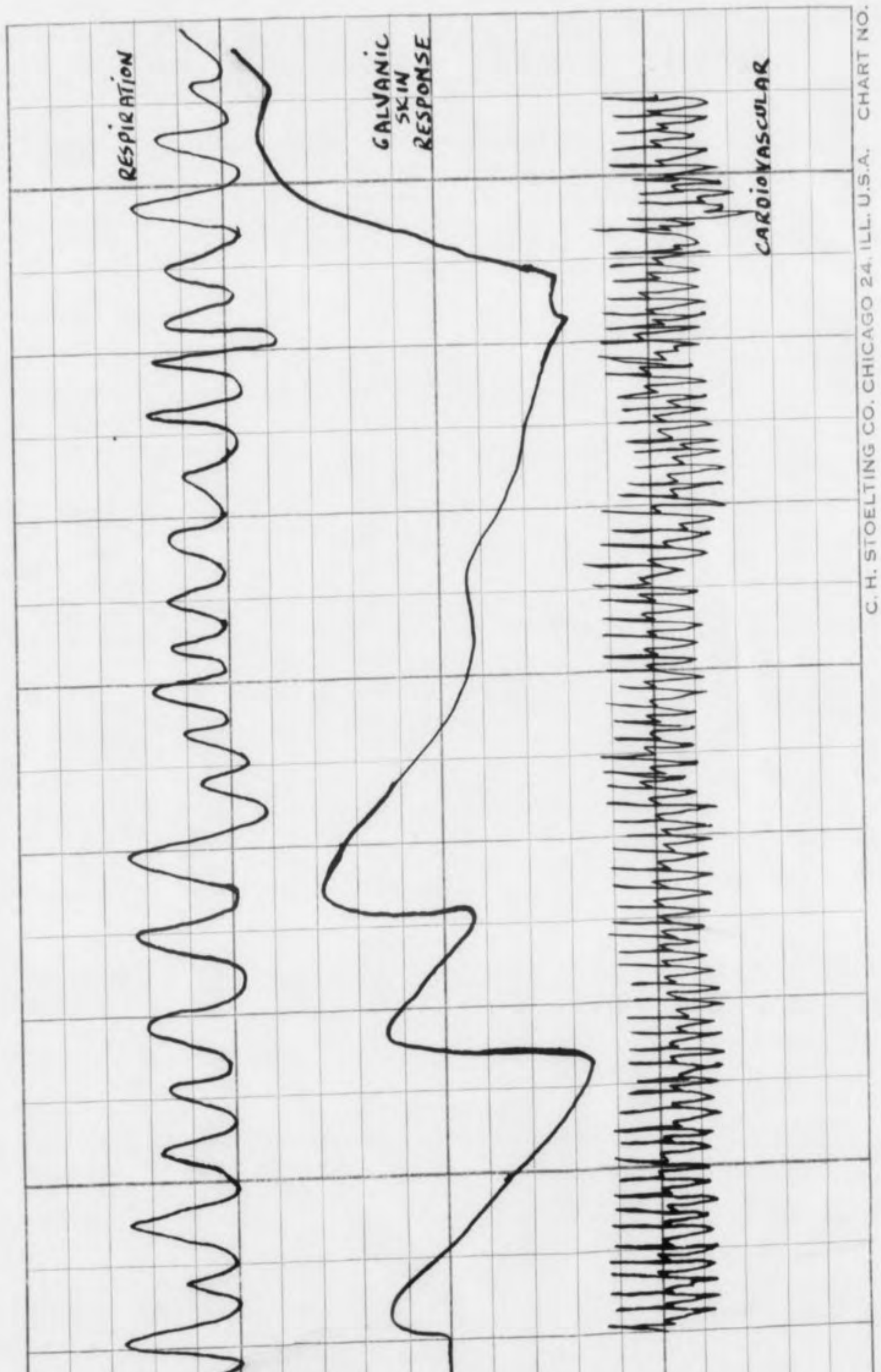
RAW DATA FOR
FINAL TEST OF ACCURACY ACTIVITY

Subject	Respiration Rate	Respiration Amplitude	Pulse Rate	Galvanic Skin Response	Blood Pressure	Activity Score
1	15	6.0	76	96	138	0
2	22	12.0	121	0	152	2.2
3	23	10.5	95	10	158	4.3
4	12	15.5	81	113	164	2.5
5	18.5	6.0	89	42	148	3.0
6	18.5	11.5	103	0	208	1.4
7	19	13.5	84	45	148	3.0
8	26	11.5	95	75	162	2.14
9	17	14.0	81	110	158	3.0
10	19.5	7.0	83	95	152	2.75
11	11	27.5	100	67	128	2.71
12	19	7.5	87	39	158	0
13	17	13.5	87	20	156	3.25
14	16.5	8.0	78	96	150	1.0
15	15	7.5	81	96	152	2.5
16	6	16.5	86	68	154	3.0
17	13.5	13.5	89	96	152	2.33
18	24	7.0	101	113	162	1.0
19	11	18.5	94	96	144	0
20	16.5	14.0	92	96	158	1.67
21	22.5	8.5	95	96	168	1.0
22	27	6.0	87	75	172	2.0
23	14.5	7.0	84	96	146	1.0
24	17.5	12.0	82	0	154	3.0
25	18	16.0	83	0	162	1.0
26	19.5	7.5	86	89	198	2.0
27	26.5	4.5	87	52	178	5.0

TABLE XX

AVERAGE PERFORMANCE SCORES

Subject	Balance	Coordination	Accuracy
1	14.4	.6082	1.8285
2	6.6	.5780	3.1200
3	5.4	.5546	1.8750
4	4.0	.4704	2.7009
5	4.0	.6212	1.9000
6	3.6	.3942	2.5000
7	5.8	.4860	2.3000
8	5.8	.5126	2.9357
9	6.6	.5757	2.1250
10	5.0	.5429	1.9583
11	2.2	.5479	1.8166
12	2.75	.4920	2.4800
13	2.6	.5088	2.2767
14	3.5	.4509	2.2333
15	2.4	.5023	2.6841
16	5.2	.4914	3.4333
17	3.6	.4867	.8750
18	4.6	.6141	2.3571
19	2.6	.4746	2.0000
20	6.4	.5944	2.5892
21	2.2	.4718	1.6667
22	9.0	.5040	1.9761
23	3.0	.4289	1.5500
24	4.4	.4558	3.3750
25	6.5	.3747	1.9333
26	4.6	.4050	1.1750
27	2.0	.5418	2.3000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