EFFECTS OF ROOM COLOR ON LEARNING AND PERFORMANCE OF TWO COMPLEX MOTOR TASKS BY FOURTH- AND FIFTH-GRADE CHILDREN

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We hereby recommend that the dissertation prepared under our supervision by Cynthia Jane Bross entitled EFFECTS OF ROOM COLOR ON LEARNING AND PERFORMANCE OF TWO COMPLEX MOTOR TASKS BY FOURTH- AND FIFTH-GRADE CHILDREN

be accepted as fulfilling this part of the requirements for the Degree of Doctor of Philosophy.

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CHAPTER I

INTRODUCTION

Achieving success in motor skills has far-reaching implications for elementary school-age children. Persons who excel in motor skills are placed in higher esteem by their peers than are lesser successful individuals (Clifton & Smith, 1962; Dittes & Kelly, 1956). The elementary educator, therefore, should attempt to control the learning environment in order to ensure motor skill success for all children.

The main purpose of the classroom-gymnasium is to offer an environment geared to the most efficient methods of learning. While the physical environment may frequently be unobtrusive, there are occasions where the intensity of the environmental stimulation may be such as to cause a disruption of the learning process (Cohen, 1968; Sommers, 1969; Spivak, 1967). Children's attention has been found to be susceptible to environmental stimuli. Capturing stimuli may become the stimulus of interest for the child and mask or conflict with less capturing stimuli necessary to accomplish a given task (Forgus & Melamed, 1966). The environmental variable of color may have considerable perceptual effect on the child.

Gerard (Note 1) carried out one of the earliest and most detailed studies on the affective and physiological responses of color in human subjects. He found that enhanced physical arousal occurred when the color stimuli were disliked and decreased arousal occurred when the color was liked. Increase in arousal was linearly associated with muscular tension, anxiety, and excitement. Obviously, a child's ability to successfully perform a motor task could be hampered in cases where the degree of arousal was excessive.

In Eysenck's (1963) examination of the effects of arousal upon motor skill learning and performance, it was shown that optimal arousal decreased with increasing task difficulty. That is to say, as the child's arousal level extended from drowsiness to alertness, there was a gradual improvement in efficiency and effectiveness of performance. But as arousal heightened to a state of excitement, Eysenck found a gradual decrease in performance. Thus, the middle range was associated with optimal performance.

Accepting the assumption that color affects learning and performance, the unanswered question appears to be to what extent will the learning and performance of motor tasks be affected when surrounded by a colorful environment?

Since the typical learning environment involves color, it would be beneficial to know whether color produces a level of arousal outside the optimal range.

Statement of the Problem

The specific problem of this study was to determine the effects of room color upon the learning and performance scores of elementary school children in a mirror tracing and a pursuit rotor task. The study was designed to answer, more specifically, the following questions:

1. Is there a significant difference in the mean learning and performance scores of boys and girls on two complex motor tasks among groups exposed to preferred colored, nonpreferred colored, and multicolored rooms? If so, which room effects will be noticeable among the three groups on each of the two motor tasks?

2. Is there a significant difference in the mean heart rate of boys and girls when performing the two complex motor tasks among groups exposed to the colored rooms? If so, will there be a correlation between heart rate and learning and performance scores among the three groups in each of the two motor tasks?

The experimental hypotheses of this study were as follows:

1. There is no significant difference in the mean

learning and performance scores of boys and girls on two complex motor tasks among groups exposed to preferred colored, nonpreferred colored, and multicolored rooms.

2. There is no significant difference in the mean heart rate of boys and girls on the two complex motor tasks among groups exposed to the colored rooms.

3. There is no interaction between the factors of order, sex, and room color when considering heart rate and learning and performance scores.

Importance of the Study

There are few studies in which the effects of color on children's motor skill learning and performance have been investigated. Of those available, most were conducted three decades ago and employed measurement techniques now known to be unreliable. Only within recent years have researchers begun to examine more systematically the many variables which may affect a child's motor skill performance (Birren, 1959, 1969). It is hoped that this study will contribute to the current building of knowledge so that the learning atmosphere of the child may be further enhanced.

Scope of the Study

The investigation was limited to 15 male and 15 female fourth- and fifth-grade volunteers, selected from a larger pool of volunteers, who were enrolled at Frank Borman Elementary School, Denton, Texas, and/or attended Denia Recreation Center, Denton, Texas, during the fall semester of the 1980-81 academic year. All of the subjects performed two motor tasks in each colored room on two different days; the order of the tasks was the same among the individuals within each of the groups. The instruments utilized to measure learning and performance were the pursuit rotor and mirror tracing devices. Heart rate was monitored throughout the treatment period and a debriefling interview was administered after all motor testing was completed. Subjects were randomly assigned to 1 of 3 groups and received treatment in the following order: Group 1 was tested in the preferred colored room, the nonpreferred colored room, and then the multicolored room; Group 2 was tested in the nonpreferred colored room, the multicolored room, and then the preferred colored room; Group 3 was tested in the multicolored room, the preferred colored room and then the nonpreferred colored room. The testing rooms were located in Room B of Denia Recreation Center, which was in close proximity to Borman Elementary School. Testing was conducted individually during the experimental sessions. The experiment was conducted during a 10-week period.

Limitations

The study was limited as follows:

1. Fourth- and fifth-grade boys and girls attending Frank Borman Elementary School and Denia Recreation Center who volunteered to participate in the study.

2. The consistency of the participants in recording color preference on the two questionnaires.

3. The specific events at school or at home that may have influenced the participants' performances between the first and second treatment sessions.

4. The cooperation of the subjects in performing to the best of their ability on each test day.

5. The reliability, objectivity, and validity of the data collection devices.

Definition of Terms

For the purpose of clarifying intended meanings of specific words in this study, the following terms were defined as follows:

Arousal was defined as a degree of cortical alertness which follows from sensory stimulation (Chaplin, 1979).

Color was defined as a collective name of the distinctive characteristics of light (Committee on Colorimetry, 1953).

Learning was defined as a rather permanent change in behavior brought about through practice or experience provided that the characteristics of the change in behavior cannot be explained on the basis of maturation, native response tendencies, or temporary states of the organism (Martens, 1971).

Manifest Anxiety Scale (hereafter designated as MAS) is a questionaire designed to measure anxiety as a general drive (Chaplin, 1979).

Multicolored Room was defined for the purpose of this study as a room with a wall painted the subject's preferred color and a wall painted the subject's nonpreferred color.

Nonpreferred Colored Room was defined for the purpose of this study as a work room painted the subject's least liked color.

Performance was defined as a measure of a motor response as indicated by scores obtained at a given point in time.

Preferred Colored Room was defined for the purpose of this study as a work room painted the color the subject liked.

CHAPTER II

REVIEW OF LITERATURE

The following studies were deemed pertinent to the discussion of color and its effect on the ability of children to learn and perform complex motor tasks. In order to present these materials effectively, the review presented below has been divided into two sections. In section one research dealing with color has been examined. This section has been subdivided into the following topical areas: (a) Color Perception, (b) Color Preference, and (c) The Effect of Color on Learning and Performance. In section two studies dealing with arousal of the individual are presented, with the subdivisions: (a) Arousal as a Concept, (b) Measurement of Arousal, (c) Arousal and Color, and (d) The Effect of Arousal on Learning and Performance.

Color

Color Perception

In 1630, the French philosopher, Descartes, attributed the color of an object to a change in the light when it reflected from the object. Until that time it had been thought that light had no color; that color belonged to objects, and light merely made it visible. The modern concept of color follows Descartes' point of view (Branley, 1978).

Color and light are psychophysical concepts which depend on both radiant energy (the psychological response) and psychophysical energy (the physical stimulus) (Burnham, Hanes, & Bartleson, 1963). Light has been described as an aspect of radiant energy capable of stimulating the retina (Alpen, Lawrence, & Walsk, 1967). Since radiant energy travels through free space without any obvious means of transmission, this form of energy is usually considered as electromagnetic waves. All electromagnetic waves, of which light is one form, travel in space at the same speed--the speed of light (186,000 miles per second). Each form of electromagnetic wave (radio, radar, x-rays, and light) has its own characteristic frequency of vibration, or wavelength, which allows an individual to distinguish between the many kinds of rays (Padgham & Saunders, 1975). Only a small number of these wavelengths are visible light; they are known as color. The length of the waves or the distance from wave crest to wave crest, determines the hue (color). The color spectrum ranges from red, which has the longest waves, through blue, the shortest waves (Burnham et al., 1963).

Color sensation may be defined as the primary conscious response to excitation of the visual mechanism (Committee on Colorimetry, 1963). The psychological aspects of color sensation are hue, saturation, and brightness. A pure color or hue distinguishes the different parts of the spectrum (red, blue, green, yellow, etc.). Hue is the dominant wavelength or the central portion of light for each color. Saturation refers to the degree of hue in a color. It is the sensation by which one distinguishes a hue as being pale or rich, weak or strong. Brightness is the primary visual sensation by which the presence of light is detected. It is associated with the quantity of light and the intensity of the visual sensation (Evans, 1948).

Although hue, saturation, and brightness are separately identified as color sensation variables, they are not independent of one another. When one variable changes, the other two are often affected (Sheppart, 1968). For this reason, room illumination and color must be carefully controlled during experimentation. Unfortunately, this cannot be done with the human eye, but must be measured with an exposure meter.

Sensation of color has been explained as the beginning of the perceptual process in the individual. During this process, the primary aspects of the stimuli, such as brightness, color, and orientation have been coded by the sensory-perceptive systems. Next, the primary aspects were combined with complex aspects, like recognition and identification, to complete the perceptual process of information extraction (Forgus & Melamed, 1976). As the individual learned and interacted with the environment, thereby gaining a broader experiential base, changes or modifications in the way the individual perceived similar stimuli also changed. Deutsch (1937) spoke of the influence of previous learning experiences and associations on attitudes toward color. These attitudes were expressed in preferences for specific colors.

Color Preference

Cohn (as cited in Pressey, 1921), working in Wilhelm Wundt's laboratory, conducted the first color preference research. From the limited number of colored gelatin plates ranked, the general consensus of color preference differed most with respect to hue. This appeared to be the trend in the early research studies of the 1900s. In summarizing these studies, Eysenck (1941) consolidated the data from 16 studies. Opinions from 21,060 subjects were computed by weighted-average order of preference from most preferred to least preferred. Blue, red, green, violet, orange, and yellow were the respective hue selections.

Similar results were reported by Navrat (1965) when determining the color preference of 160 children, ages 3 to 10 years. Primary hues were, in order of preference: blue, red, green, and yellow. The sex of the children had little or no effect on the color choice. This finding has been supported by Garth, Moses, and Anthony (1938), Granger (1955), Kagan and Lemkin (1961), and Norman and Scott (1952).

Generally, the contention, until the last 15 years, was that children's color preference was developmentally set (Beebe--Center, 1932; Burnham et al., 1963; Byersted, 1960; Ruddock, 1965). Specifically, the researchers found "preferences to develop and shift with age showing a tendency to move from warm to cooler colors with increasing years" (Burnham et al., 1963, p. 212). Because of variations in and uncertainty of the dimensions of the color stimuli used in the studies, researchers began to examine more closely other factors which could influence children's preferences in color. One such investigation was conducted by Child, Hansen, and Hornbeck (1968). The authors asked children, representing grades 1 through 12, to indicate their personal preferences within each pair of colors shown. The pairs differed on one or two of the three dimensions of color. The findings indicated no such age change when the dimensions were varied independently; all children preferred the cool colors. Most warm colors had higher saturation values than most cool colors; thus, the child who seemingly liked warm hues may have been responding to high saturation.

The studies reported above focus on the color preferences of children. The duration of attention given to the preferred choices was investigated by Mazumdar and Chatterjee (1962). Four colored discs, red, green, yellow, and blue, were mechanically rotated a uniform distance from the subjects. They were instructed to respond verbally when they observed the appearance and disappearance of a spot on the third ring of each disc. The duration between responses was kymographically recorded for the 60 readings. A positive correlation (.80) was found to exist between the attention-duration and the color preference. Thus, children attended longer to their preferred color.

The Effect of Color on Learning and Performance

According to the psychological literature, learning associations tend to affect attitudes toward colors as expressed in color preference (Eismen, 1955; Staples & Walton, 1933). In turn, color preferences and color associations mediate physiological responses to color (Deutsch, 1937; Gerard, Note 1). Pleasant and unpleasant color stimuli therefore produce an affective as well as physiological reaction in the human. These reactions may affect the learning process and performance of the child.

Learning and performance are often mistakenly considered to be synonymous terms. Literature in psychology and motor learning, however, provides a distinct difference of meaning. Learning has been defined as a relatively permanent change or modification in the internal state of the individual as a result of practice or past experience at some activity or task, provided these changes are not the result of maturation, native response tendencies, or temporary states of the individual (i.e., drugs, fatigue, etc.) (Hilgard & Bower, 1975; Schmidt, 1975; Singer, 1968). Performance has been described as "a temporary occurrence fluctuating from time to time because of many potentially operating variables" (Singer, 1968, p. 10). Hence, a task has been considered learned when there is no change in performance.

Since learning occurs covertly, measurements can only be obtained indirectly. Performance scores must be used, therefore, as a measure of the overt changes that have been observed. In the research described below, performance scores were used as indices of motor performance.

Motor Performance

In many of the color cue studies, subjects performed a task while colored lights were turned on intermittently. One of the earliest studies was reported by Pressey (1921). Red, green, and blue stimulus lights were switched on, individually, 45 seconds after a finger tapping task had begun. Other tasks included multiplication, free association, and repeating nonsense syllables. No influence of color on pulse rate, respiration, or performance was discovered.

Interpretation of these results should be made with caution since the study was conducted over a 2-year period with no regard for diurnal effects. Of the 26 subjects tested, only 4 to 6 were used in each task. Finally, there were no powerful statistical procedures available at that time.

In a more recent investigation, Bross and Jackson (Note 2) examined the effects of room color on the performance of a complex motor task. Fifty, seventh-, eighth-, and ninth-grade girls performed a mirror tracing task until a criterion score was reached. Upon achieving the required score, the subjects were tested, individually, in their preferred and nonpreferred colored room. Three additional trials on the mirror tracer were given in each room.

Two two-by-three ANOVAs with repeated measures on room color were employed to analyze the time and error data. The junior high girls made significantly fewer errors in their preferred colored room. Only minimal differences in time to complete the task were recorded, however.

The remaining literature in this section does not deal directly with environmental effects of color on motor performance. The author felt it necessary, nevertheless, to inform the reader regarding known knowledge about color and performance in relation to objects within the environment.

A unique method of testing the effects of color on writing performance was devised by Krzesni (1973). One hundred third-grade and one hundred sixth-grade Canadian children were randomly given a blue, red, green, and black pen, or a pencil. They were instructed to record the color of the pen they preferred on the paper provided, and then write a 10-minute story about a camera, which was placed in front of the class. In addition, they filled out a questionnaire.

Analysis of the data showed that the number of letters written in the story were not significantly different between pen colors, although pen scores were better than pencil scores. Stories written in green produced better scores than any other color. Seventy-six percent of the third graders and 49% of the sixth graders felt they would perform better with their favorite color; however, the findings proved otherwise. Krzesni concluded and then suggested that children should be permitted to write with a writing instrument of their choice.

Target color was varied in an experiment conducted by Shick (1976). Thirty-nine volunteer college women were asked to perform an overhand or sidearm throw at a 20-inch square target, which was mounted on the wall 25 feet away. A regulation softball was thrown at a red, a yellow, a blue, a green, a black, and a white target. A trial consisted of 10 throws, each at a different colored target.

Ten trials were completed in a 10-day period. The subjects' total hits did not vary significantly between colors. Shick then noted that the findings did "in no way address the more complex issue of the effects of multicolored targets on performance" (p. 390).

Ball color and catching ability was the subject of investigation by Isaacs (Note 3), Morris (1976), and Schoney (Note 4). Isaacs (Note 3) tested the effects of ball size, ball color, and preferred color on the catching ability of 7- and 8-year-old boys and girls. Each subject was randomly assigned a 6-, 8½-, or 10-inch colored ball. Eight catching trials for each colored ball (red, blue and red, and blue stripes) were evaluated according to a modified version of the Hellweg catching scale. The Snellen test of visual acuity and the Isihihara's Test for Colour Blindness were administered prior to testing.

An analysis of the data showed the influence of ball color to be minimal on children's catching ability. In addition, smaller ball sizes promoted a more mature style of catching than did the larger balls. A sex difference, favoring the males, also was found.

Background color (black, white) and plastic ball color (yellow, blue, white) were varied in Morris' (1976) study to determine the effect color had upon catching. Unlike the results obtained from Isaacs (Note 3), this researcher found a significant difference in catching when both yellow and blue balls were used. Highest scores were recorded when blue balls were projected against a white background; and males performed significantly better than females in this task.

The effect of ball color (royal blue, jade green, scarlet) and direction of projection were investigated by Schoney (Note 4). Twenty-four male and twenty-four female volunteers, ranging in age from 8.5 to 11.5 years, were initially classified according to high, medium, or low ability to catch 12 grey balls. A Ball Boy was used to project six balls of each color to the left, right, and center of the body. Prior to testing each subject was asked to choose a preferred color from the three available. The influence of ball color and color preference on catching ability were not found to be significant, however, the direction the object was projected, skill level, and sex were affected significantly.

Motor Learning

The author conducted a thorough search of the literature, but found no research which dealt specifically with the effect of color on motor skill learning. However, Ketcham (1958) reported a longitudinal study concerned with the effect of color and scholastic achievement. This author selected three school buildings that needed painting. School A was left untouched; the walls and ceiling of school B were painted a light buff color, while the walls in school C were painted yellow, green, and blue. After a 2-year period, children in the color coordinated school, school C, demonstrated a marked improvement in scholastic achievement. Kindergarten children in school C showed a 33% improvement over the 2-year period.

Arousal

Arousal as a Concept

In the 1940s, many psychologists discarded the word emotion due to difficulty in developing a working definition

(Duffy, 1961; Hebb, 1955; Lindsley, 1951; Malmo, 1959; Schlosberg, 1954). Researchers agreed that the word emotion often designated the fact that someone was aroused to some degree. Therefore, the terms arousal and/or activation were utilized to provide a framework in which emotional phenomena could be discussed.

Initially, arousal was defined "as the extent of release of potential energy, stored in the tissues of the organism" (Duffy, 1962, p. 17), as demonstrated in activity or response. The term was inadvertently associated with vigorous overt activity, therefore, the definition was restated "as the extent of release of the stored energy of the organism through metabolic activity in the tissues" (Duffy, 1962, p. 18).

Behavior varies in direction or intensity. The degree of arousal deals specifically with the intensity characteristic of behavior. Observable variations in arousal occur in a continuum from deep sleep or coma to extreme excitement (Lindsley, 1952). The level of arousal present is often inferred from observation of the muscular response which takes place. Given the occurrence of an overt motor response, the intensity of the response can be measured in terms of its duration, the number of times it takes place during a chosen period of time, or overall speed of the response.

The degree of potential energy stored in the tissues can also be measured in terms of duration of the response, its frequency of occurrence, or the latency of its appearance. Thus, a relationship should exist between the measurable qualities of the overt motor response and the underlying physiological concomitants.

<u>Measurement of Arousal</u>

Direct measures of the intensity of a response may be achieved through physiological measures such as: (a) autonomic functions, (b) skeletal-muscle functions, and (c) functioning of the higher nerve centers. Arousal has been found to be a function of the integration of these entities (Duffy, 1934, 1941, 1951; Freeman, 1949). Ordinarily, a change in one measure correlates with changes in the other measures, although the intercorrelational coefficients have been quite low (.12) (Ax, 1953; Boon, Fisher, & Mumford, Note 5). When the system is stimulated by something in the environment, the whole system reacts due to the communication pathways connecting all parts of the organism (Burnham et al., 1963; Kohler, 1935; Sherrington, 1929).

Effects of arousal are diffused throughout the organism; therefore, several different techniques are utilized to measure activation levels. Assessment techniques have been divided into three categories: (a) biochemical indicators, (b) physiological indicators, and (c) behavioral indicators and subjective report (Duffy, 1957). Hormonal changes in blood sugar and urine have been used as biochemical indicants of arousal (Elmadjian, Hope, & Lanson, 1957; Lykken, 1968). Heart rate (Lykken, 1968), blood pressure (Davis, Buchwaldt, & Frankman, 1955), muscle tension (Woodworth & Schlosberg, 1954), cortical activity (Lansing, Schwartz, & Lindsley, 1956; Mundy-Castle, 1953), skin response (Ax & Wenger, 1955; Lykken, 1968), and palmar sweating (Darrow, 1936; Darrow & Freeman, 1934) have served as physiological indicators. The behavioral indicators, which are generally identified by an observer or by self-report measures include: (a) trembling, (b) cold sweat, (c) muscular tension, (d) palpation of the heart, and (e) dryness of the mouth (Shaffer, 1947).

Heart Rate

Heart rate, as a physiological indicator of arousal, measures the frequency of cardiac activity. Traditionally, investigators have used the EKG period from R wave to the next R wave as the interbeat interval; with this interbeat interval, the most elemental heart rate in beats per minute may be calculated (Burdick, 1978).

As utilized in many experimental situations, heart rate assessment via FM telemetry has allowed recording of the subject's heart rate in an unrestricted condition in the experimental setting (Ainsworth, Bell, & Stayton, 1971; Ornitz & Ritvo, 1968). Normally, subjects are given time to adapt to the electrodes while in a waiting room, thereby making it possible to determine the heart rate to the experimental situation (Sroufe & Waters, 1977).

Heart rate has been a popular and effective measure of arousal over the years (Elliott, 1972). Generally, the aroused individual exhibits a significant increase in heart rate level, while the less aroused individual demonstrates a significant decrease in heart rate (Burdick & Scarbrough, 1968; Cameron, 1941; Elliott, 1970; Ornitz & Ritvo, 1968; Taylor & Epstein, 1967). In addition, arousal due to environmental acceptance and rejection (Lacey, 1959; Sage & Bennett, 1973), muscular tension (Freeman, 1948; Lovass, 1960; Sage & Bennett, 1973), and environmental color stimuli (Alexander, as cited in Birren, 1969; Birren, 1959; Deutsch, 1937; Goldsmith, 1942; Ott, 1968; Gerard, Note 1) have also been found to affect heart rate levels.

Lacey (1950) found isolate patterns of response to exist within the individual, and each pattern was stable over a period of time. Therefore, more than one technique of measuring arousal has been recommended.

Subjective Ratings

Subjective reports of behavioral arousal have consisted primarily of questionnaires and interviews assessing feelings and sensations (Martens, 1974). One of the foremost investigations using the report method was devised by Shaffer (1947). Aerial pilots were asked to state all physiological changes they were conscious of during combat missions. Thirty percent of the subjects reported a pounding heart, rapid pulse, tense muscles, and dryness of the throat or mouth as they flew over enemy territory.

Emotional responses of football players and wrestlers were solicited in a study by Harmon and Johnson (1952). Pre-contest reports from 42 subjects throughout the repective seasons correlated well with galvanic skin response, pulse rate, and systolic blood pressure as indicators of emotional excitation.

Affective responses, while viewing colored lights, were recorded by Gerard (Note 1). Subjective reactions to color appeared to reflect the objective changes in physiological activity.

Arousal and Color

Every individual has a unique way of reacting to environmental stimuli and of perceiving those stimuli that determine the emotional response (Forgus & Melamed, 1966).

Reactions to color stimuli, such as red and blue, have induced different levels of arousal both in the autonomic nervous system and in the brain (Goldstein, 1942). Similar results were found by Fere (1900). In his experimental study of 10 subjects, autonomic arousal and muscular pressure increased as a result of viewing colored lights in the sequence from blue, to green, yellow, orange, and red.

In a detailed investigation Gerard (Note 1) studied the relationship between color and emotions as well as between color and the activation of the entire organism. Specifically, Gerard wanted to determine whether the projection of red, blue, and white lights on a diffusion screen would evoke differential affective and physiological responses in the subject. Twenty-four male undergraduate subjects were randomly divided into six groups, with each group given a different color sequence. The testing room was totally dark. Measurements were made of blood pressure, palmar conductance, respiration, heart rate, muscular activation, frequency of eyeblinks, and EEG waves. During rest periods the subjects reported subjective feelings about the colors.

In analyzing the physiological measures it was found that: (a) blood pressure increased under the influence of red light and decreased under blue light; (b) both blue and red produced an immediate increase in palmar conductance, although after a period of time red light produced higher amounts than blue; (c) respiratory movements increased under exposure to red light and decreased during blue; (d) red illumination increased the frequency of eyeblinks and blue decreased the frequency; (e) no appreciable difference in heart rate was found between the colors; however, heart rate was faster under red than under white light, and white light generated faster heart rate than blue; and (f) cortical activation (EEG waves) was affected when all lights were introduced; however, after 10 minutes of exposure to the colors, activation was consistently greater for red than blue light.

The affective responses were significantly related to the autonomic measures. Reported feelings of drowsiness, relaxation, calm, and positively toned associations were related to lessened physiological arousal; while feelings of alertness, tension, anxiety, excitement, and negatively toned associations occurred with increased arousal.

Performance of Complex Motor Tasks

In the motor learning domain, Martens (1974) has attempted to explain, in two hypotheses, the relationship between levels of arousal and motor performance. The first, known as the drive theory, has remained "operationally nonfunctional for complex motor behavior" (p. 174) because of the inability of the researchers to specify habit hierarchies for motor responses (Bolles, 1967; Cofer & Appley, 1964; Martens, 1971; Spence, 1971). The inverted-U theory, however, has received great support in studies on motor learning (Hebb, 1972; Martens, 1974).

Yerkes and Dodson (1908) used dancing mice as subjects to test the relation of stimulus strength to rate of learning. Weak, medium, and strong shock stimuli were studied to determine the strength most favorable to acquiring a discrimination habit. The findings clearly pointed to the medium stimulus as a favorable strength for learning and performance. All subjects who trained under strong and weak stimuli learned more slowly than those trained under the medium strength stimulus. These findings led to the formation of the "Yerkes-Dodson Law" (Yerkes & Dodson, 1908). Simply stated, the "law" proposed that optimum arousal for learning and performance decreased with increas- task difficulty (Oxendine, 1968). A similar proposal was made by Broadhurst (1959) and Freeman (1940) and has been widely accepted as an arousal theory for human performance.

The Yerkes-Dodson Law has incorporated the inverted-U hypothesis in explaining the relationship of level of arousal and motor performance. Generally, as an individual's arousal level extends from drowsiness to alertness, a gradual improvement in efficiency and effectiveness of performance occurs. Performance, however, decreases as arousal approaches a state of excitement. Hence, the middle range has been associated with optimal performance (Sage, 1971).

Different arousal states seem to have varying effects in different performance situations. Some factors affecting performance are: (a) nature of the arousing stimuli, (b) characteristics of task, (c) differences in individuals, and (d) level of skill proficiency. Researchers have studied each factor separately to gain a better understanding of the effect of motivation (Fisher, 1976; Martens, 1974; Oxendine, 1968; Sage, 1971).

Variety of stimuli appear to sustain the arousal state over a period of time. Mackworth (1964) tested subjects over a prolonged period of time on a number of tasks under conditions of little variation in stimulus. Performance significantly declined as time increased.

Numerous studies have focused on related vs. unrelated response arousal (Marteniuk, 1969; Marteniuk & Wenger, 1970; Powell, 1974; Sage & Bennett, 1973). Generally, in these experiments a procedure in which arousal was induced by application of electric shock was used. The "related arousal" groups were administered shock if they did not improve performance scores (tracking on a pursuit rotor, squeezing a hand dynamometer) by a specified percent, whereas "unrelated arousal" groups received electrical shock randomly following certain trials regardless of their performance (Marteniuk, 1969; Sage & Bennett, 1973). Results supported the supposition, proposed by social psychologists Schachter (1959) and Berkowitz (1969), that arousal affected performance only when it was related to the response; when arousal was unrelated to the response, performance was not affected. Marteniuk and Wenger (1970) nevertheless found contradicting evidence. In their study they neglected to determine whether the administration of shock was actually arousal producing for their subjects, which may explain the divergent results.

A sensori-motor task was performed under noise and quiet conditions in a study by Grimaldi (1958). The stimuli condictions varied in frequency ranges and intensities. When noise was presented, more errors and less precision was evident; intermittent noise had an even greater effect on performance. Moreover, quick and precise response times were slower and number of errors greater when noise levels and frequencies were high.

A second factor affecting the relationship of arousal and motor performance was the characteristics of the task. According to Fiske and Maddi (1961), two dimensions of the task must be considered in determing optimal arousal level for maximal performance: (a) the amount of energy necessary to undertake the task and (b) the difficulty of the task. These authors have postulated that "the more difficult the task, the narrower the range of optimal arousal for maximum performance" (p. 179). Further, if the physical energy requirements are combined with increasing task difficulty, the optimal range will be even narrower.

Unfortunately, there has been little research to validate the writings of Fiske and Maddi (1961). Oxendine (1970), an expert in the field of motor learning, has speculated on the following: (a) high level of arousal is essential for optimal performance in gross motor tasks involving strength, endurance, and speed, (b) high level of arousal interferes with performance involving complex skills, fine muscle movements, coordination, steadiness, and general concentration, and (c) slightly above average level of arousal is preferable to a normal or subnormal arousal state for all motor tasks.

During initial skill learning, high arousal may have a detrimental effect on performance. These findings were reported by Lazarus, Deese, and Osler (1952) in an extensive review of cognitive and motor skill learning literature. In summarizing the studies, the authors reported that arousing stimuli introduced early in the learning process have been found to be detrimental to performance, but stimuli presented late in learning facilitated performance. Similar results also were reported by Marteniuk (1969), Ryan (1961), and Sage and Bennett (1973). These investigators administered electric shock as the arousing stimulus and found a less disruptive effect on performance late in learning.

The final factors affecting the arousal-performance relationship are categorized as individual differences. The personality disposition of trait anxiety (relatively stable anxiety proneness) has become important in determining the responsiveness of an individual to arousal-eliciting stimuli and, thus, possibly inhibiting an individual's ability (Martens, 1974). Tests of arousal effects on complex and fine controlled movements have proved equivocal. Carron (Note 6) reported detrimental effects in balance performance of high anxiety college males when an electric shock was introduced; whereas low anxiety subjects were unaffected. However, the detrimental effect on the high anxiety subjects appeared to fade late in the learning period. In summary, the researchers stated that in tasks of low difficulty, high anxiety subjects were found to be superior to low anxiety subjects; and low anxiety subjects performed best in tasks of high difficulty. Similar results were reported on a complex motor task (Bergstrom, 1967), a tracking task (Pinneo, 1961), reaction to a discrimination task (Stabler & Dyal, 1963), and a mirror tracing task (Singh, 1968).

Trait anxiety groups were tested on a fencing lunge and recovery task in a study devised by Slevin (Note 7). Speed and accuracy were judged under various experimental conditions. Performance under all of the conditions was significantly better for the low-trait anxiety group than the high-trait group.

In contradiction to the previous studies, Harrington (1965) failed to find significant differences in performance on a balance task among low-, medium-, and high-anxiety women. These findings were substantiated by Martens and Landers (1970) when three trait anxiety groups consisting of junior high boys performed a difficult tracing task under high, moderate, and low stress conditions.

Conclusions drawn by Duffy (1962) have remained accurate:

> It appears, then, that it is impossible to state what particular level of activation is most conducive to good performance. The answer might be considered to depend upon the requirements of the task at the moment, and certain characteristics of the individual, some of which may be temporary and others more or less permanent. If the assumptions made up to this point are tenable, it seems certain that there is an "optimal"

> level of activation for a given task to be performed by a given individual at a given time. It would appear also that for most individuals and for most tasks the optimal level is a moderate degree of activation, high enough to assure reasonable speed and alertness, and low enough not to present a hazard to the organization of responses. (pp. 193-194)

Motor Learning

A "Perseveration-Consolidation" theory of learning has been utilized as an explanation for beginning and highly skilled learning and performance under conditions of arousal. Walker and Tarte (1963) described an interrelationship between arousal, perseverative consolidation, and action decrement. Their theoretical point of view, which follows, was based primarily on verbal learning investigations and research conducted with animals.

> The occurrence of any psychological event, such as an effort to learn an item of a paired-associate list, sets up an active, perseverative trace-process which persists for a considerable period of time.
>
> The perseverative process has two important dynamic characteristics: (a) permanent memory is laid down during this active phase in a gradual fashion; (b) during the active period, there is a degree of temporary inhibition of recall, ie., action decrement (this negative bias against repetition serves to protect the consolidating trace against disruption).
>
> High arousal during the associative process will result in a more intensely active trace process. The more intense activity will result in greater ultimate memory but greater temporary inhibition against recall. (p. 113)

To date, few examinations have been made using a motor learning task. Martiniuk and Wenger (1970) partially confirmed this theory. Thirty subjects were divided equally into three groups: (a) related arousal, (b) unrelated arousal, and (c) control group. Each subject performed 20 trials on the pursuit rotor on day 1 and then 10 further trials on day 2, approximately 24 hours later. Trials 1 to 5, and 16 to 20 (Day 1), and 1 to 10 (Day 2), were stress free. Subjects in the related groups were told they would have to improve their scores 5% over the previous best score, or otherwise receive a shock. Subjects in the unrelated group were told they would receive a shock immediately following certain trials.

The analysis from day 1 showed all groups were learning at a significant rate. Learning scores from day 2 revealed a significance between groups for both learning scores calculated. Statistically, there was a difference between the experimental groups (related and unrelated) and the control group for learning score 1. However, only the differences between the related and the control group were significant for learning score 2. There was no difference between the two stress groups for either learning score. This finding was contrary to expectations. The investigators thought that the related arousal group's performance would be facilitated while that of the unrelated arousal group would demonstrate no change or a decrement during day-1 trials.

Sage and Bennett (1973) conducted a study similar to the Marteniuk and Wenger (1970) investigation. The only procedure different from that of the previous study was the administration of the A-State form of the State-Trait Anxiety Inventory to determine if the induced-arousal was anxiety evoking. The authors thought this may have been a weakness in the Marteniuk and Wenger (1970) experiment. Analysis of the results indicated that electric shock administration significantly enhanced arousal of the related arousal group over the control group but not the unrelated arousal group. Performance was not affected by either arousal condition. Learning rate was significantly enhanced in the related arousal group over the control group but not affected in the unrelated arousal group.

CHAPTER III

METHODS OF PROCEDURE FOR COLLECTION OF DATA

The present study was designed to determine the effects of room color upon learning and performance scores of fourth- and fifth-grade males and females on a mirror tracing task and pursuit rotor task. The study was planned to determine specifically whether (a) differences in performance and learning scores would result in preferred colored, nonpreferred colored, and multicolored rooms; (b) differences in heart rate would result during performance and learning in the preferred colored, nonpreferred colored, and multicolored rooms; and (c) differences in heart rate, performance, and learning scores would result on two complex motor tasks between males and females in preferred colored, nonpreferred colored, and multicolored rooms.

The following methods of procedure were utilized to aid in the analysis and interpretation of derived data as evidence of the effects, if any, which color had upon the learning and performance scores of elementary school males and females on two complex motor tasks. The methodology is described under the following headings: (a) Preliminary Planning for the Study, (b) Selection, Description, and

Administration of the Research Instruments, (c) Training of Assistants, and (d) Experimental Procedures.

Preliminary Planning for the Study

Selection of Subjects

Subjects were selected on the basis of the following critera: (a) no previous experience with the motor skills of tracking and mirror tracing; (b) fourth- and fifth-grade status while attending Denia Recreation Center, Denton, Texas; (c) willingness to attend the experimental sessions; (d) consistent color preferences as demonstrated on two color questionnaires; and (e) completion of the MAS and the debriefing interview.

Permission was obtained to solicit subjects for the study from the Human Research Review Committee, a University committee charged with the responsibility of approving University related research and investigations involving human subjects. In addition, permission to test was procured from the Denton Independent School District, the principal of Frank Borman Elementary School, and the director of Denia Recreation Center. Copies of these forms may be found in Appendix B. A request for subjects was made by sending parental consent forms home to the total population of fourth- and fifth-grade students enrolled in Frank Borman Elementary School, Denton, Texas. Employees at Denia Recreation Center, Denton, Texas, also aided in the search for subjects by announcing and distributing consent forms to participants attending recreational activities.

Of the 251 children who received a consent form, 81 positive responses were returned within the 7-day limitation. From the positive responses (39 males and 42 females) 17 males and 17 females were randomly selected to serve as subjects. The males ranged in age from 121 to 147 months with a mean age of 130.2 months. The average age of the female subjects was 123.6 months with a range from 109.3 to 142.8 months.

The following procedure was utilized in the random assignment: 47 volunteers, who had completed the MAS and had consistent color responses on both color preference questionnaires, were categorized according to preferred and nonpreferred color. The volunteers' last names were listed in alphabetical order and numbered from 1 through 47. Subjects were then randomly assigned to treatment conditions using a table of random numbers (Minium, 1978). The first 17 males and 17 females were selected. All 34 of the volunteers agreed to participate; however, 4 were ill and missed the testing sessions.

Each subject who agreed to participate in the study was contacted personally by telephone. At that time, a brief introduction by the director of the study was made to participants to (a) acquaint the subjects with the director, (b) arrange testing schedules, (c) present the study as a method of testing the performance of motor tasks, and (d) encourage promptness in reporting to the testing area at the appropriate time. Every effort was made to create interest in and a feeling of anticipation toward the experiment.

<u>Assignment of Subjects</u>

The subjects were randomly assigned to one of three experimental groups and received treatment in the following order: Group 1 was tested in the preferred colored room, nonpreferred colored room, and then the multicolored room, Group 2 was tested in the nonpreferred colored room. the multicolored room, and then the preferred colored room, and Group 3 was tested in the nonpreferred colored room, the multicolored room, and then the nonpreferred colored room. Order of testing was determined by a Latin-Squares technique to control for a possible order effect (Winer, 1971).

The following procedure was employed in this random assignment. It had been planned to classify subjects according to sex and anxiety level (high, medium, low), based on scores obtained from the MAS. However, since all of the participants scored in the moderate anxiety range it was possible for the investigator to ignore anxiety level as an independent variable and group the subjects only by sex.

Site of Data Collection

The collection of data for this study was carried out in Room B in Denia Recreation Center, Denton, Texas. The recreation center was in close proximity to Frank Borman Elementary School, Denton, Texas, and many of the students participated in recreational activities after school between 2:45 and 6:00 pm each day. The subjects were tested at this time and also during the physical education class period. Each testing session lasted approximately 45 minutes.

The pretest meetings and all treatment sessions were conducted in Room B of the recreation center. The room was painted white, a neutral color thought to produce the least amount of thought associations (Gerard, Note 1). Each of the three colored rooms (preferred, nonpreferred, and multi-colored) were stationed within this large room. The rooms were triangular shaped with two changeable walls to accommodate the various colors; a white curtain served as the third wall. Figure 1 presents the floor plan of Room B. Each subject sat with his/her back to the curtain and faced the opposing corner. In the preferred and nonpreferred colored rooms the walls were painted in accordance with the subject's preferred and nonpreferred color. In the multicolored room, the wall on the subject's right was painted in accordance with his/her nonpreferred color and the wall on his/her left was painted the preferred color.

A Weston Direct Reading Exposure meter was used to determine the illumination of the testing rooms. Rooms were checked before testing began each day to maintain similar conditions. Additional lighting was used when necessary.

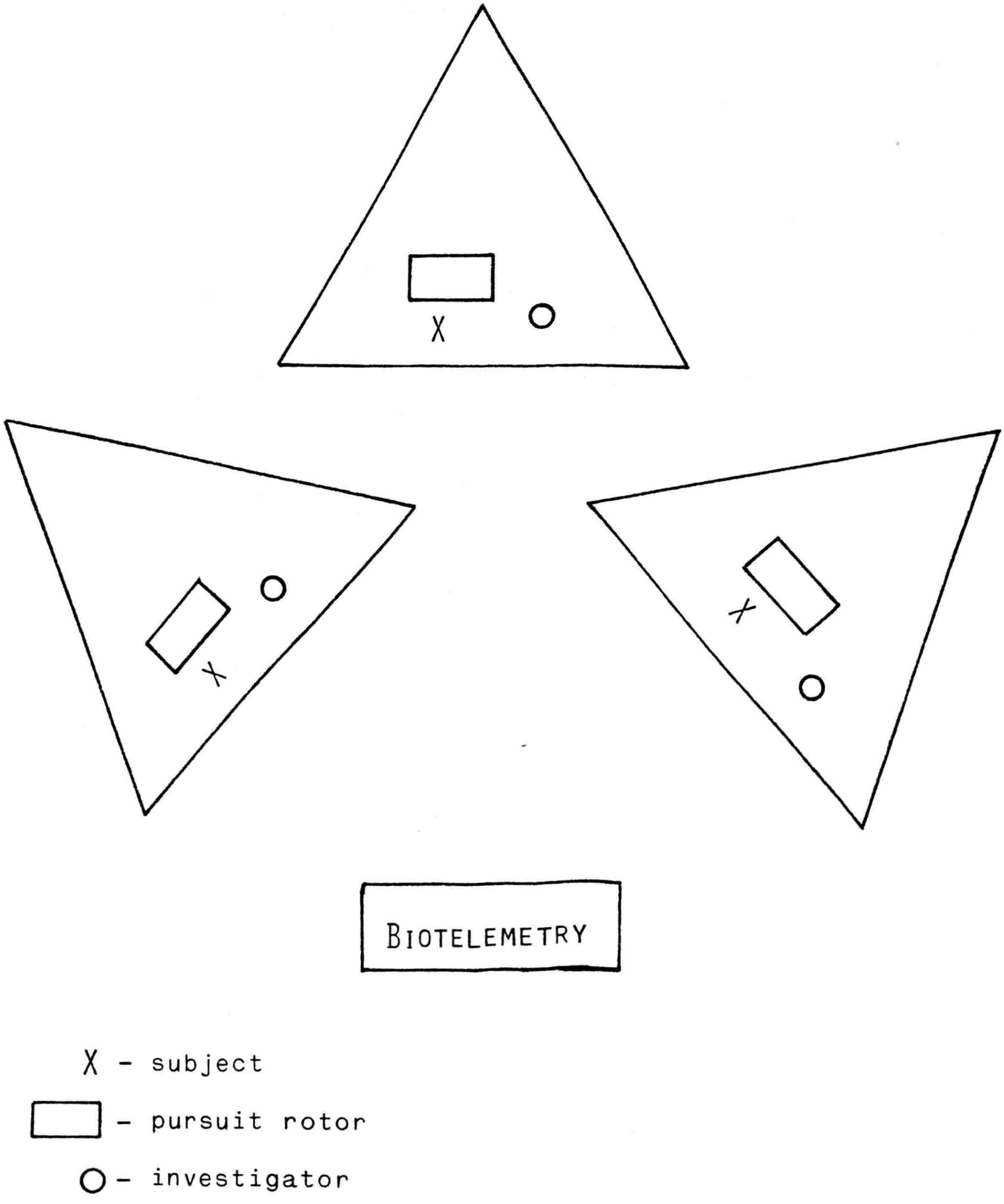

Figure 1. Testing Room

Selection, Description, and Administration of the Research Instruments

Selection and Description of the Classification Instruments

Color Chart

Selection. The color chart utilized in this study was designed with the following criteria in mind: (a) it should present a selective representation of colors for the age group, (b) colors should be distinguishable and dissimilar from one another, and (c) the chart should provide a visual choice of the preferred and nonpreferred color.

In order for the investigator to provide a selective representation of colors to the subjects, a survey of 25 fourth-grade males and females was conducted prior to the pretest meetings. Previous studies dealing with color preference have used the hues of blue, red, yellow, green, violet, orange, brown, and black (Eysenck, 1963; Navrat, 1965; Bross & Jackson, Note 2). The students were therefore given eight cards with a different hue (blue, red, yellow, green, violet, orange, brown, black) and five saturations of that hue on each card. Instructions were to select two from each card. The colors that received 50% or more of the votes on each card were used in the color chart. The black saturations did not receive the required majority; therefore, the black hue was represented by itself. A total of 15 colors were selected for the color chart.

Description. The color chart used in this study was a 26 by 26 by 1/8 inch white board. Fifteen 4 by 5 by ½ inch boards were each painted in one of the selected colors. The colored boards were randomly arranged in four rows and four columns. A vacant space was located in the second row, third position from the left, due to the uneven number of colors.

A number was assigned to each color to simplify the identification process. The numbers, 1 through 15, were located ¼ inch above the center of each color board.

Color Preference Questionnaire

Selection. The color preference questionnaire was designed specifically by the investigator for the purpose of gaining information concerning the subjects' color preference. Appendix A contains a copy of the questionnaire. A questionnaire similar to the one utilized in this study provided a reliable test-retest method of attaining color preference (Bross & Jackson, Note 2).

Description. The questionnaire posed two questions: (a) If you had your choice, which color room would you like to work in?, and (b) If you had your choice, which color room would you least like to work in? Below each question, a line was provided for the number of the color the subject had selected.

Ishihara's Test for Colour-Blindness

Selection. The Ishihara's Test for Colour-Blindness (Ishihara, 1979) was used in this study due to its validity as a good screening device (Foster, 1946; Walls, 1959), administratability (Isaacs, Note 3), and use in normal daylight and electric light (Ishihara, 1979). In addition, the test directions were simple enough for 9- to 12-year-old children to understand.

Description. The Test consisted of a series of 14 plates designed to give a quick and accurate assessment of color vision deficiency of congenital origin. Each plate contained a circle, 3½ inches in diameter, filled with two or more different hues and/or saturations of dots. Eleven of the circles contained one or two digit numerals in a hue and/or saturation different from the remaining dots; these numeral(s) were in the center of the circle. The remaining three circles were filled with winding lines of various hues and/or saturations.

Children's Manifest Anxiety Scale

Selection. Birren (1978) stated that high, medium, and low anxiety individuals are affected differently by color sensation. Thus the scores from a children's anxiety scale, based on the scale norms, enabled the investigator to classify the subjects into high, medium, and low anxiety groups.

The Children's Manifest Anxiety Scale (Cantanada, Palermo, & McCawdlers, 1956) was selected with the following criteria in mind: (a) the scale should be applicable for fourth- and fifth-grade students, (b) the scale should provide quantitative measurability for which scoring can be obtained objectively, (c) the scale should be quickly and easily administered and scored, and (d) the scale should possess acceptable levels of validity and reliability. A copy of the Scale may be found in Appendix A.

In 1951, Taylor used the Minnesota Multiphasic Personality Inventory as a basis for the development of the MAS. It was one of the first anxiety inventories to be developed and put into general use. Buss (1955) found the Scale to be valid for general populations, having validity coefficients of .60 and .57. Hoyt and Magoon (1946) also found the Scale to be valid when compared with counselor ratings.

Cantanada, Palermo, and McCawdlers (1956) revised the MAS to make it applicable for fourth-, fifth-, and sixth-graders. A test-retest method revealed a reliability ranging from .70 to .94 with an average of .90.

<u>Description</u>. The Children's Revision Form of the MAS consisted of 42 questions that were selected and modified

from the MAS. These questions were answered "yes" or "no" and an anxiety level was obtained from the summation of the number of "yes" answers. Norms for the subjects were set with the 50th percentile distribution at 16, the 80th percentile distribution at 25, and the 20th percentile at 10. The 30 subjects in the presently reported investigation scored in the moderate range level, thereby eliminating the need to classify according to anxiety level.

Administration of the Classification Instruments

Color Chart, Color Preference Questionnaire, and MAS

Three and four weeks prior to the motor testing sessions, pretest meetings were held for all subjects who had returned the parental consent form. The two meetings were held on a Monday during the fourth- and fifth-grade physical education class periods. The color chart, color preference questionnaire, and the MAS were used in the first pretest meeting. Only the color chart and the color preference questionnaire were used in the second pretesting meeting. Approximately 20 subjects were administered the MAS and Questionnaire each session; there were five sessions each day. Assistant A gave each subject a personal information form (Appendix A), a color preference questionnaire, and MAS when he/she entered Room B. The Assistant was the only person who dealt with the subjects in the pretest meeting.

This arrangement was utilized in order to minimize associations being made between the color preference questionnaire, the investigator, and motor testing.

Ishihara's Test for Colour-Blindness

All of the subjects were administered the Ishihara's Test for Colour-Blindness on the first day prior to performing the motor tasks. The color plates were held approximately 30 inches from the subject and tilted so that the plane of the paper was at right angles to the line of vision. The numerals which were seen on plates by the subject were stated, and each answer was to be repeated within a 3-second interval. Plates with winding lines were traced with the subject's finger (Ishihara, 1979).

A correct reading of 10 or more plates was considered normal color vision. Color vision was regarded as deficient if seven or less plates were read correctly. All subjects in this investigation obtained passing scores. Had a subject failed the test, he/she would have been replaced by another randomly selected individual.

Selection of Motor Tasks

The complex motor tasks utilized in this study were selected with the following criteria in mind: (a) tasks should be new to all subjects, (b) tasks should include target skills, (c) tasks should be challenging to all levels yet not so difficult as to limit the improvement of performance by all levels of skill, (d) tasks should provide quantitative measurability for which scoring can be obtained objectively, and (e) tasks should possess acceptable levels of reliability.

The investigator was concerned with the consistency of the effects of room color on motor tasks; therefore, two novel tasks were selected. Target tasks were selected because children are involved in some type of target activity during most of their waking hours (Dauer & Pangrazi, 1979). Some of the target activities involve stationary targets while others involve moving targets. The motor tasks utilized in this study were mirror tracing (stationary target) and tracking on a pursuit rotor (moving target).

The investigator was not interested in the effect one motor task had on the other, but rather what effect room color had on the learning and performance of motor tasks. The order of "on task" practice, therefore, remained the same throughout the experiment. The mirror tracing task was performed first and the pursuit rotor task was performed second.

Singer (1975) and Oxendine (1968) stated that the pursuit rotor and the mirror tracing devices are the most commonly used laboratory tasks in motor learning research.

Each task is a novel task and can be learned to a reasonable degree of proficiency in a short period of time.

Description of Motor Tasks

Mirror Tracing

Instrument. A Marietta Mirror Tracer (Model 5-5) was used in the study. This apparatus consisted of an aluminum plate with a smooth metal five-point star pattern located slightly below the surface. The plate and the metallic tracing stylus were both connected to the control unit. A metal shield prevented the subject from looking directly at his/her hand and arm movement. The mirror stood perpendicular to and at the top of the star pattern.

Task. The task of mirror tracing involved tracing, with a metallic stylus, between a double outline (½ inch wide) of a five-point star pattern while looking into a mirror. The star appeared reversed and inverted in the mirror. The subject could not look at his/her hand while performing the task. Instructions were given to trace the star in a clockwise direction as quickly and accurately as possible. Running time, which was time in contact with the star pattern, and error time, which was time outside the star pattern, were recorded for each of the six trials in each room.

Instructions. The following instructions were given to each subject: "Please sit directly in line with the mirror tracer and hold the stylus in your preferred hand. At the beginning of each trial, when the command 'Ready' is given, place the tip of the stylus on the white starting mark and trace in a clockwise direction until the white stopping mark is reached. Trace the star figure as quickly and accurately as possible without lifting the stylus from the star. If the stylus is removed, the clocks will stop and the trial must be repeated. At the end of each trial place the stylus on the table and relax until the 'Ready' cue is given. The entire procedure will then be repeated. There is a 20-second rest period between each of the six trials in the three rooms."

Pursuit Rotor

Instrument. A Lafayette Photoelectric Pursuit Rotor (Model 2203E) was used for one of the learning and performance tasks. The apparatus consists of a turntable containing a rotating disc resting over a circular light. A template, which lies flush with the top surface of the turntable, was a black sheet of glass. Located in the center of the glass was a clear 9 1/8 inch isosceles triangle with broken corners. The light, which shined through the triangle, was pursued by the subject with a light sensative stylus that was connected to the apparatus.

Total time "on-target" was recorded in hundredths of seconds by a Lafayette Digital Stop Clock (Model 54015). Each 20-second testing interval was initiated by a single tap on a telegraph key which in turn started the Lafayette Interval Timer (Model 58010). The interval timer started and stopped the digital clock at the end of 20 seconds.

Task. The task involved tracking the photoelectric light, moving in a clockwise direction around the triangle at 40 rpms, with the light sensitive stylus. Total time "on-target" was recorded for each of the six 20-second trials in each room. There was a 20-second rest period between each trial.

Instructions. The following instructions were given: "Please sit comfortably beside the pursuit rotor and hold the stylus in your preferred hand. At the beginning of each trial when the command 'Ready' is given, pick up the stylus and place it in the middle of the turntable. After a 2-3 second interval, the command 'Go' will be given. On command, attempt to keep the tip of the stylus in contact with the rotating light for as long as possible. At the end of each 20-second testing interval the command 'Stop' will be given. There will be a 20-second rest period between each of the six trials in each of the three rooms. The entire procedure will then be repeated."

Administration of Motor Tasks

All subjects in all groups performed two motor tasks on two different days, with both tasks assigned each day. The order of tasks was kept the same within each group; however, the room order varied between groups.

Each subject attended one of the following scheduled sequences for administration of the tasks: Monday and Wednesday or Tuesday and Thursday. Subjects were scheduled at specific times, either during the physical education class or after school, and maintained the same appointment time on both days. The investigator and Assistant B were the only persons present in Room B during the experiment. Each subject was tested individually.

The 30 subjects were tested on both tasks under an experimental condition with no practice warm-up trials by any of the subjects prior to the performance of each task. All subjects received a total of 36 trials with a 20-second rest between trials in the mirror tracing task and a total of 36 20-second trials with a 20-second rest between trials on the pursuit rotor task. The subjects performed 6 trials in each of the 3 rooms in both motor tasks each day.

Selection of the Instruments to Measure Arousal

There exists in the literature relative to arousal, many valid and reliable techniques used to measure activation level (Duffy, 1957). The following criteria were adhered to in the selection of instruments: (a) administrative feasibility of equipment, cost, ease of scoring, personnel, and ease of administration during school time, (b) appropriate for age level of subjects, (c) ease of interpretation of results, and (d) acceptable reliability and validity.

Two techniques were selected. The techniques were heart rate, a physiological measure, and a debriefing interview, a subjective measure. The literature has supported the use of heart rate as an effective physiological measure of arousal only when used in conjunction with other measurements (Duffy, 1957). Therefore, a debriefing interview, which has been used frequently in arousal and color research, was also employed to gain quantitative information (Birren, 1978; Duffy, 1957; Rice, 1953; Gerard, Note 1).

Description of the Arousal Instruments

Heart Rate

The rate at which the subject's heart beat was measured by an electrocardiogram (EKG). Electrodes, which were attached to the subject's chest, translated electrical activity from the heart into impulses that were then recorded on a strip of moving paper.

For the purpose of this investigation, telemetry was used as a means of monitoring heart rate. Telemetry allowed the subjects to be ambulatory and eliminated the problem of cumbersome cables by employing a pocket size, battery operated radio transmitter. The transmitter was attached to the subject's waistband. The electrodes, attached to the transmitter, were silver--silver chloride, .5 inch in diameter. One electrode was placed on the subject's lower sternum, the second was placed on the left sixth intercostal. Transmission of electrical activity was received by a Narco Bio-Systems Receiver (Model FM 1100-7) which was directly connected to a Narco Bio-Systems Physiograph (Model DMP-4A). The physiograph was used to obtain a continuous recording of each subject's heart rate. The polygraph paper ran at a constant speed of .25 cm/sec.

Debriefing Interview

The debriefing interview, developed by the investigator, was used to determine each individual's subjective impressions and feelings while in the learning environment. A copy of the debriefing interview may be found in Appendix A. The interview consisted of 10 statements which asked questions dealing with (a) which testing room was liked and disliked, (b) in which testing room was performance the best and the poorest, (c) which room color was liked and disliked, (d) what were the subject's feelings in each testing room, and (e) what aided performance the most.

Administration of the Instruments to Measure Arousal

Heart Rate

Heart rate was monitored throughout the testing sessions on both days. Assistant B was responsible for electrode placement, monitoring the recordings, and maintaining all heart rate equipment. This procedure was to ensure reliability and validity between testing days and among all subjects.

Researchers have suggested a resting period up to 5 minutes, before testing, to allow time for the heart to reach the basal level (Larsen, 1974; Martens & Landers, 1920; Sroufe & Waters, 1977; Wood & Hokanson, 1965). During the testing time, while each subject was sitting with electrodes in place, Assistant B monitored and recorded the heart rate. When the rate was acceptable (83.5 bpm for females and 89.0 bpm for males at 10 years of age), the remainder of the experiment was begun (Larsen, 1974). An additional resting period (approximately 30 seconds) was given upon entering each testing room to allow the rate to again reach the basal level.

Debriefing Interview

All subjects were administered the debriefing interview immediately after all motor testing had been completed the second day. After the electrodes had been removed, a subject was asked to sit down and answer a few questions before leaving Room B. Each statement was asked by the investigator and all responses were written on the available form. A tape recording was made of each interview.

Training of Assistants

Two women assisted the investigator in data collection for the experiment. Both were experienced in dealing with children. Major factors in the choice of Assistant A were her ability to help during school hours and her familiarity with the conduct of the pretest meetings. The major factors in the choice of Assistant B were her knowledge of motor learning equipment and research, her dependability, and availability during school hours.

Assistant A reported for a 1-hour session during which specific instructions for the administration of the instruments were reviewed and practiced. Assistant B received 10 hours of training and practice on electrode placement and application, and equipment operation.

A pilot study was conducted a week before actual testing began. The instructor and Assistant B tested three students who were not subjects in the investigation. The purpose of this activity was to become acquainted with the entire testing procedure and to establish reliability of performance.

Experimental Procedures

Pretest Meeting Procedures

The first meeting was conducted 4 weeks prior to testing. Assistant A asked all of the volunteers to enter Room B and sit in the chairs made available for them. After everyone had been seated, the assistant collected the parental permission forms and distributed a personal information form, color preference questionnaire, MAS, and a pencil to the children. They were asked to fill out the personal information form first. After all had completed the personal information form, they were instructed to read the directions for the MAS very carefully and circle either "Yes" or "No" next to each statement. Finally, the children were asked to look at the color preference questionnaire while the following instructions were given: "Please look at the 15 colored squares on this board. Each colored square is numbered. After reading the first question look at the board and find the color you <u>like</u> and write the number of that color on the line below the question. Now read the second question and find the color that you <u>least</u> <u>like</u> and write the number of that color on the line below the question." After everyone had completed the color questionnaire, the assistant collected all of the forms and reminded the subjects to return next week at the same time.

The second meeting was held 3 weeks prior to testing. The assistant administered the questionnaire and gave the same instructions. While the assistant collected the questionnaires, she told the children they would be notified of the testing schedule at a later date.

Motor Testing Procedures

The investigation consisted of two major phases: (a) initial testing on the mirror tracing apparatus and pursuit rotor to attain performance scores and (b) 2 days later, a retest on the same tasks to attain the learning scores. The experimental sessions were conducted in the same room throughout the entire experiment in order to maintain consistent stimuli conditions.

Initial Test

The following procedure was followed on the first day of testing: When the subject entered room B he/she first received a brief explanation and demonstration on the heart rate apparatus and electrode placement. He/she was asked to sit quietly while the electrodes were attached to his/her chest. A 5-minute resting period, with the electrodes in place and the physiograph operating, helped the investigator establish a basal heart rate. During the 5-minute rest, the investigator administered the Ishihara Colour-

Blindness test. The subject and investigator then moved into the first testing room and the subject sat comfortably in the testing chair until the baseline rate was again achieved (approximately 30 seconds). During this resting period the investigator gave instructions and a demonstration on the use of the mirror tracing device. When the heart rate reached the established baseline the assistant, operating the telemetry apparatus, informed the investigator. At that time, the subject began testing on the mirror tracing device. Six trials, with 20 seconds rest between each trial, were performed on the mirror tracer in each colored room.

After completing the six trials, the subject and the investigator walked to the second testing room, which was approximately 10 feet away, and the subject rested until the heart rate reached the baseline. The subject performed six more trials on the mirror tracer in this room before moving to the third colored room. The same procedure was repeated a final time.

On completion of the mirror tracing task in the third colored room, the subject moved back to the first room and rested while the investigator gave instructions and a demonstration on the use of the pursuit rotor. The same testing procedure was followed for the pursuit rotor. The subject performed six trials in each colored room on the task.

At the end of the testing period the electrodes were removed. The subject was asked to return in 2 days, at the same time, for additional testing.

Retest

The testing procedure for the second day followed the same format as the first day. At the end of the testing period the subject was given the debriefing interview before leaving the testing area.

CHAPTER IV

PRESENTATION, INTERPRETATION, AND ANALYSIS OF DATA

The purpose of this investigation was to determine the effect of preferred colored, nonpreferred colored, and multicolored rooms on mirror tracing and pursuit rotor learning and performance scores of fourth- and fifth-grade males and females. Subjects were 30 students from Frank Borman Elementary School in Denton, Texas. The subjects were randomly assigned to groups and received treatment in the following order: Group 1 was tested in the preferred colored room, nonpreferred colored room, and then the multicolored room, Group 2 was tested in the nonpreferred colored room, multicolored room, and then the preferred colored room, and Group 3 was tested in the multicolored room, preferred colored room, and then the nonpreferred colored room. Heart rate was monitored throughout the treatment period, and a debriefing interview was administered after all motor testing was completed. Testing was conducted individually during the 10-week experimental period.

Each subject within each group was administered 18 total trials (6 trials per room) on each motor task on Day 1, and 18 total trials (6 trials per room) on Day 2. Day 1 trials were analyzed as performance scores and Day 2 trials were treated as learning scores.

The data were utilized to test the following null hypotheses:

1. There is no significant difference in the mean learning and performance scores of boys and girls on two complex motor tasks among groups exposed to preferred colored, nonpreferred colored, and multicolored rooms. Supported.

2. There is no significant difference in the mean heart rate of boys and girls on two complex motor tasks among groups exposed to the colored rooms. Supported.

3. There is no interaction between the factors of sex, order, and room color when considering heart rate and learning and performance scores. Failed to support.

The presentation of the analysis of the data has been divided into four major phases: (a) Performance Scores, (b) Learning Scores, (c) Heart Rate, and (d) Debriefing Interview. In testing the null hypotheses, the .05 level was chosen as the criterion for significance. All computer support for this study was provided by the Computer Center, Texas Woman's University, Denton, Texas. Statistical analyses were performed on the DEC System-20 computer. A three dimensional repeated measures design (Lindquist Type III) with repetition on the C (room) dimension was used to analyze the data. The specific program employed was entitled "BMDP2V", which was prepared by Robert Jennrich and Paul Sampson, Health Center Computing Facility, UCLA.

Performance Scores

The purpose of the motor performance analysis was to determine the effects of room color on mirror tracing and pursuit rotor performance scores of both male and female children. Analysis of the performance scores from the first day of testing are presented below.

Mirror Tracing

Descriptive data on the mirror tracing performance scores are presented in Table 1. The mean total time scores were higher for males and females, Group 1, in the preferred colored room with mean values of 56.1 and 61.7 seconds. Group 2 males and females exhibited higher mean values of 27.9 and 44.6 seconds in the nonpreferred colored room, while Group 3 males and females had the greater times in the multicolored room with mean values of 38.4 and 37.1 seconds. The large standard deviations indicated a marked degree of variability in scores in each colored room.

Table 1

Description of the Mirror Tracing Total Time Performance Scores in Seconds

Subject Sex and Group	Preferred M	Preferred SD	Nonpreferred M	Nonpreferred SD	Multicolored M	Multicolored SD
Group 1						
Males	56.1	23.2	13.7	3.7	14.7	13.4
Females	61.7	30.4	34.9	13.4	26.6	10.9
Group 2						
Males	12.3	8.3	27.9	17.4	15.7	10.3
Females	17.0	11.8	44.6	27.7	25.6	12.7
Group 3						
Males	23.9	13.4	19.1	8.9	55.0	38.4
Females	33.7	23.2	24.7	17.9	51.3	37.1

Summaries of the analysis on mean performance scores for mirror tracing are presented in Table 2. Nonsignificant main effects of order and sex were found within the repeated dimension of the analysis. In addition, the order-by-sex interaction was not significant.

Examination of the repeated dimension failed to reveal a significant main effect of room or interactions of room-by-sex and room-by-order-by-sex. The room-by-order interaction, however, was significant. The observed F value of

16.56 with 4 and 48 degrees of freedom was found to be significant beyond the .001 level. This interaction effect was anticipated because of the differential effect order of testing had on the room variable.

Table 2

Three Dimensional Repeated Measures Design Repetition on the C Dimension for the Mirror Tracing and Pursuit Rotor Performance Scores

Source	df	Mirror Tracing MS	Mirror Tracing F	Pursuit Rotor MS	Pursuit Rotor F
Among Subjects					
Order	2	1155.59	1.53	1.80	.61
Sex	1	1849.06	2.44	11.60	3.94
Order x Sex	2	162.80	.21	2.58	.88
Error	24	757.41		2.94	
Within Subjects					
Room	2	334.55	1.37	.43	1.31
Room x Order	4	4034.97	16.56*	7.30	22.38*
Room x Sex	2	166.99	.69	.45	1.38
Room x Order x Sex	4	98.97	.41	.48	1.49
Error	48	243.63		.33	

*$p < .001$

Figure 2 shows a performance curve of total time required to complete the mirror tracing task in seconds as a function of successive trials for the three conditions of the experiment. Inspection of this figure indicated that the subjects in all groups greatly improved in their performance on trials 1 through 18 for Day 1. In addition, the performance curves suggest that the subjects performed similarly during the experimental period regardless of the room color. The curves for trials 19 through 36 on Day 2 show very little improvement in performance; this indicates that the task had been learned.

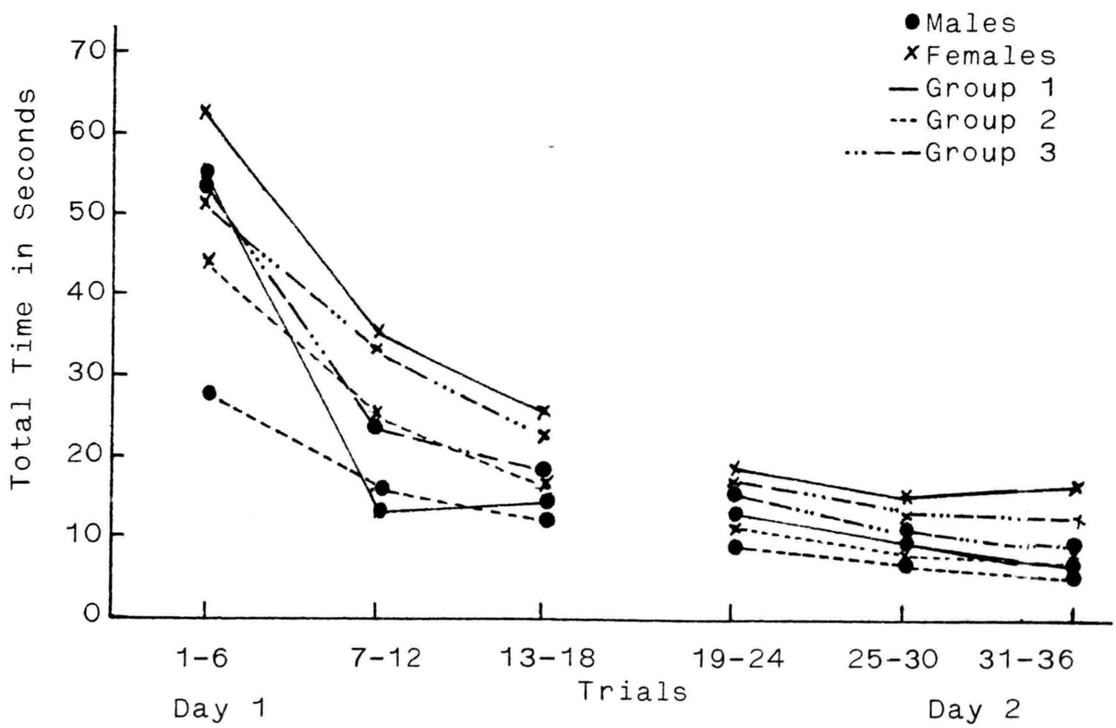

Figure 2. Mirror Tracing Performance Curve--Days 1 and 2.

Pursuit Rotor

Means and standard deviations of the mean pursuit rotor performance scores are presented in Table 3. Examination of the table showed Group 2 males and females exhibited the highest mean time-on-target scores in the preferred colored and multicolored rooms with mean values of 2.8 and 2.0; and 2.5 and 1.9 seconds respectively. Group 3 males and females performed best in the nonpreferred colored room with mean scores of 3.3 and 1.4 seconds. Variability of the subjects was indicated by the size of the standard deviations.

Table 3

Description of the Pursuit Rotor Time-on-Target Performance Scores in Seconds

Subject Sex	Preferred		Nonpreferred		Multicolored	
and Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Group 1						
Males	1.1	.7	1.6	.9	2.0	1.3
Females	.6	.4	1.4	1.2	2.0	1.7
Group 2						
Males	2.8	1.6	1.1	.9	2.5	1.3
Females	2.0	1.5	.9	.6	1.9	1.0
Group 3						
Males	3.0	1.4	3.3	1.2	1.4	.9
Females	1.5	.9	1.4	.7	.6	.2

Table 2 contains the analysis of variance summary table for mean performance scores on the pursuit rotor task. Main effects of order and sex were not significant within the nonrepeated dimension of the analysis. The order-by-sex interaction also was found to be nonsignificant. Investigation of the repeated dimension failed to reveal a significant main effect of room, as well as nonsignificant interactions of room-by-sex and room-by-order-by-sex. The room-by-order interaction was significant with an observed $\underline{F}$ value of 22.38 with 4 and 48 degrees of freedom ($p < .001$). This finding demonstrated the differential effect of order as a function of room color.

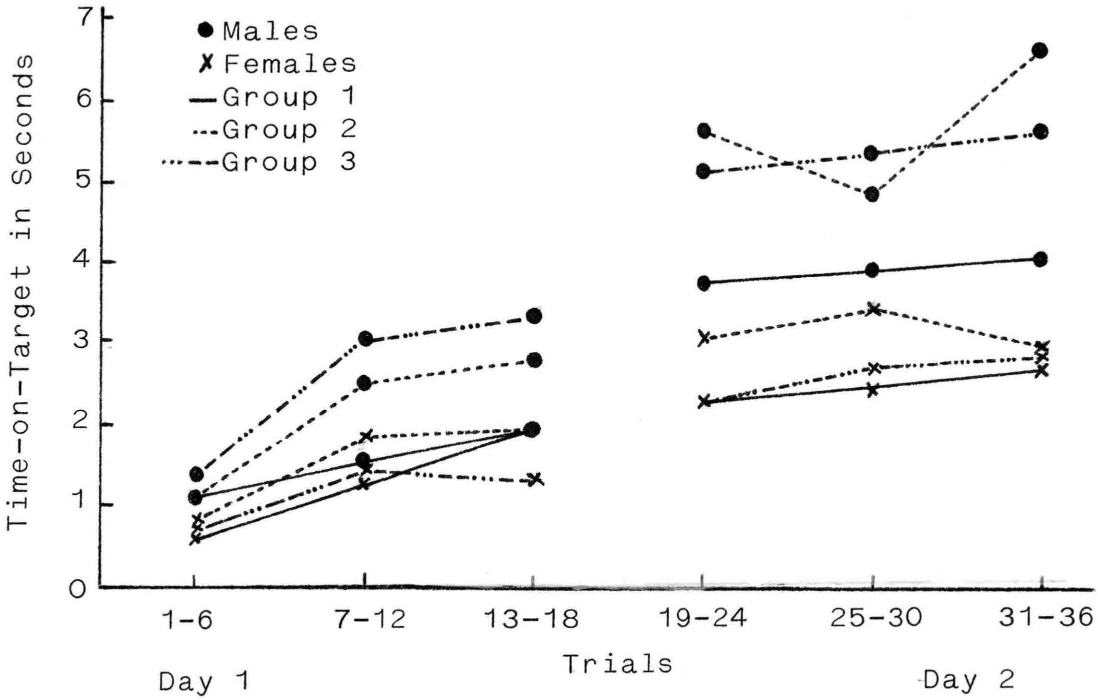

Figure 3. Pursuit Rotor Performance Curve--Days 1 and 2.

Pursuit Rotor

Figure 3 represents the performance curves from the pursuit rotor scores. The figure shows a plot of time-on-target in seconds as a function of successive trials for the three conditions of the experiment. Examination of the curves indicated that all groups greatly improved in their performance on trials 1 through 18, Day 1. In addition, the subjects performed similarly during the experimental period regardless of the room color. The curves for trials 19 through 36 indicated that learning of the task was still occurring. In addition, performance of the male subjects was superior to that of the female subjects.

Summary of Results of Performance Scores

The increasingly better performance evident for all of the subjects in each colored room on the motor tasks indicated that practice facilitated task performance (Oxendine, 1968; Sage, 1971, Singer, 1975). However, no significant differences in the increase in performance between groups or sex occurred as a result of room color. These findings substantiate the earlier results of Bross and Jackson (Note 2), in which no difference in total time to complete the mirror tracing task was found in the preferred colored and the non-preferred colored rooms.

Significant differences in the room-by-order interaction were expected because of the method utilized to control for an order effect. Results indicated that no specific order of testing was more beneficial or detrimental to performance on the motor tasks.

Learning Scores

The purpose of the following analysis was to determine the effect of room color on the learning process of mirror tracing and pursuit rotor tracking. Three learning scores, obtained from Day 2 performance scores, were calculated to ascertain the effect of room color on learning. The mean of trials 19 through 24 minus the mean of trials 1 through 5 constituted the second learning score; and the mean of trials 31 through 36 minus the mean of trials 1 through 5 constituted the third learning score. This method of calculating a learning score has been used in motor learning research by Marteniuk and Wenger (1970) and Sage and Bennett (1973).

Mirror Tracing

Table 4 describes the groups in relation to their mean performance on the mirror tracing task. A study of Table 4 revealed that Group 1 males and females exhibited the highest mirror tracing learning scores with 44.3 and 42.3, 46.8 and 45.7, and 49.3 and 44.7 seconds. The standard deviations for the three groups were large which indicated variability in scores.

Table 4

Description of the Mirror Tracing Learning Scores

Subject Sex and Group	Preferred *M*	Preferred *SD*	Nonpreferred *M*	Nonpreferred *SD*	Multicolored *M*	Multicolored *SD*
Group 1						
Males	44.3	27.9	46.8	27.9	49.3	25.1
Females	42.3	27.5	45.7	29.0	44.7	27.5
Group 2						
Males	21.2	16.5	18.9	15.7	20.6	16.3
Females	32.9	22.6	31.9	22.0	33.4	22.5
Group 3						
Males	22.1	9.4	23.9	9.2	18.3	10.1
Females	35.8	24.8	36.2	24.6	32.9	21.0

Summaries of the analysis of variance on learning scores for the mirror tracing task are presented in Table 5. Nonsignificant main effects of order and sex as well as the order-by-sex interaction were found to exist within the non-repeated dimension of the analysis.

Examination of the repeated dimension of the analysis showed the main effect of room, and the interactions of room-by-sex and room-by-order-by-sex to be nonsignificant; the room-by-order interaction, however, proved significant. The observed *F* value of 8.59 with 4 and 48 degrees of freedom was significant beyond the .001 level.

Table 5

Three Dimensional Repeated Measures Design Repetition on the C Dimension for Mirror Tracing and Pursuit Rotor Learning Scores

Source	df	Mirror Tracing MS	F	Pursuit Rotor MS	F
Among Subjects					
Order	2	3333.25	2.30	6.02	.82
Sex	1	1385.25	.96	66.13	9.02*
Order x Sex	2	611.53	.42	3.05	.42
Error	24	1449.73			
Within Subjects					
Room	2	5.96	1.09	.66	.97
Room x Order	4	46.92	8.59**	1.34	1.67
Room x Sex	2	.40	.07	1.53	2.24
Room x Order x Sex	4	6.22	1.14	1.12	1.65
Error	48	5.46		.68	

*$p < .006$

**$p < .001$

Figure 4 graphically represents the room-by-order interaction effect on the mirror tracing learning scores. Application of the Tukey test comparisons showed that, for Group 1, mean learning scores were significantly ($p < .05$) greater than those of Groups 2 and 3 in each colored room.

This finding appeared to indicate that Group 1 demonstrated greater learning after trials 1 through 6 than Groups 2 and 3.

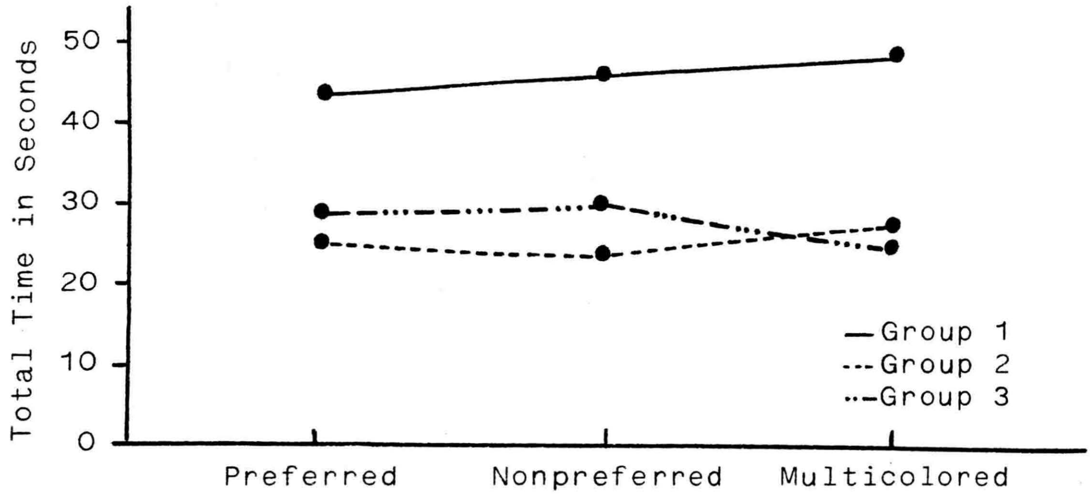

Figure 4. Room-by-Order Interaction Effect on Mirror Tracing Learning Scores.

To further investigate the effects of room color on children's learning of the mirror tracing task, an analysis was conducted on the mirror tracing performance scores from the second day (trials 19 through 36) of testing. A graphic illustration of the scores is presented in Figure 2. Summaries of the analysis on the mean performance scores on the mirror tracing task are found in Table 6.

Table 6

Three Dimensional Repeated Measures Design Repetition on the C Dimension for Mirror Tracing Performance Scores--Day 2

Source	df	MS	F
Among Subjects			
Order	2	208.09	.97
Sex	1	559.70	2.60
Order x Sex	2	60.18	.28
Error	24	215.47	
Within Subjects			
Room	2	5.99	1.10
Room x Order	4	47.02	8.62*
Room x Sex	2	.39	.07
Room x Order x Sex	4	6.22	1.14
Error	48	5.46	

*$p < .001$

Nonsignificant differences were evident in main effects of order, sex, and room. No significant interaction effects existed for order-by-sex, room-by-sex, and room-by-order-by-sex. A significant ($p < .001$) room-by-order interaction effect was found to exist within the repeated dimension.

To probe for significance within the interaction of room-by-order, the Tukey analysis was applied to the mean differences. The post hoc analysis revealed that no order (group) was significantly superior in the mirror tracing task on the seond day of treatment. These findings demonstrated that the three groups were approximately at the same ability level at the end of the experimental treatment period. The significant learning score, therefore, did not result in superior ability for Group 1. This leads to the question: If initial performance was approximately the same for all groups and final performance was approximately the same for the groups, how did Group 1 achieve a greater learning score?

A possible answer to this question would be that the performance scores for Group 1 were lower, although not significantly so, than those of Groups 2 and 3. Inspection of Figure 2 revealed that this was indeed the case. Group 1, which was tested initially (trials 1 through 6) in the preferred colored room, received slower times on the mirror tracing task than the other two groups. This, then, explains why Group 1 displayed greater learning than Groups 2 and 3.

Pursuit Rotor

Descriptive data on the pursuit rotor learning scores are presented in Table 7. Inspection of the table showed

Group 2 exhibited higher learning scores than Groups 1 and 3 in the preferred colored and multicolored rooms with mean values of 5.5 and 2.0, and 3.7 and 2.5 seconds, respectively. Group 3 demonstrated the highest learning score in the nonpreferred room with mean values of 4.2 and 2.1 seconds. The large standard deviations revealed a marked degree of heterogeneity between the subjects' scores in each of the colored rooms.

Table 7

Description of the Pursuit Rotor Learning Scores

Subject Sex and Group	Preferred <u>M</u>	<u>SD</u>	Nonpreferred <u>M</u>	<u>SD</u>	Multicolored <u>M</u>	<u>SD</u>
Group 1						
Males	2.9	2.2	2.8	2.1	2.9	2.5
Females	1.7	1.8	1.8	2.0	2.0	2.3
Group 2						
Males	5.5	1.6	3.6	1.7	3.7	2.1
Females	2.0	1.1	2.1	.9	2.5	1.0
Group 3						
Males	4.1	1.1	4.2	.5	3.8	1.2
Females	1.9	1.7	2.1	1.8	1.7	1.4

Summaries of the analysis of learning scores for the pursuit rotor task are presented in Table 5. A significant main effect of sex was found to exist within the repeated dimension of the analysis. The observed F value of 9.02 with 1 and 24 degrees of freedom was significant beyond the .006 level. The main effect of order and the interaction of order-by-sex were significant. The repeated dimension of the analysis failed to reveal a significant main effect of room or any significant interaction effects.

To probe the significant main effect of sex, mean scores of the two sexes were compared. This comparison yielded a mean time-on-target of 3.70 seconds ($p < .05$) for males, while the females obtained a mean time-on-target score of only 1.99 seconds. Thus, male pursuit rotor learning scores were significantly superior to those of the female.

Summary of Results of Learning Scores

Slight improvement in mirror tracing and pursuit rotor learning scores was evident for all of the subjects in each colored room, although the improvement was not of a magnitude to be significantly different. Both males and females in Group 1 recorded higher learning scores than Groups 2 and 3 on the mirror tracing task. This indicated that perhaps initial performance in a preferred colored room may have temporarily affected learning of the motor task, but, not to the extent that proved detrimental to final performance.

Male superiority in tracking on a pursuit rotor after interpolated rest has been documented (Ammons, Alprin, & Ammons, 1955; Buxton & Grant, 1939). Results of this study further substantiate this claim. Males in this investigation displayed greater learning than females on the pursuit rotor task; this finding appeared to be independent of room color.

Significances in the room-by-order interaction occurred in the analysis of mirror tracing learning scores. This was expected because of the method used to control for order effect. The room-by-order effect was not found significant, however, in the pursuit rotor analysis. This indicated that although there was variability between groups (order) within each colored room, it was not of a magnitude to be significant.

Heart Rate

The third phase of the analysis of data was conducted to determine if heart rate varied significantly among subjects exposed to preferred colored, nonpreferred colored, and multicolored rooms while learning and performing a mirror tracing and a pursuit rotor task. Analysis of the mean heart rate during performance in each colored room are presented for both days of testing. In addition, the relationship between heart rate and motor performance are examined.

Mirror Tracing

The means and standard deviations on the heart rate scores (Day 1) are presented in Table 8. Examination of the table revealed that Group 1 males and females experienced a higher mean heart rate score than Groups 2 and 3 in each colored room. Heterogeneity of the subjects was indicated by the large standard deviations of the three groups.

Table 8

Description of the Heart Rate Scores during Mirror Tracing--Day 1

Subject Sex and Group	Preferred M	Preferred SD	Nonpreferred M	Nonpreferred SD	Multicolored M	Multicolored SD
Group 1						
Males	100.8	10.0	100.1	6.7	97.2	6.1
Females	100.9	10.4	101.3	10.9	100.6	7.8
Group 2						
Males	98.9	6.5	100.7	3.9	98.5	5.8
Females	103.4	9.3	99.3	11.3	100.9	10.4
Group 3						
Males	96.2	12.7	96.1	11.6	94.5	11.1
Females	98.6	12.0	95.9	12.9	99.9	15.2

Summaries of the analysis on mean heart rate during the first day of performance on the mirror tracing task are presented in Table 9. Neither the main effects of order and sex nor the order-by-sex interaction approach significance within the nonrepeated dimension of the analysis. An evaluation of the within subjects dimension revealed a nonsignificant main effect of room as well as nonsignificant room-by-order and room-by-order-by-sex interactions. The room-by-sex interaction, however, was significant beyond the .02 level. This indicated variability in heart rate between males and females in each colored room because of order of presentation.

Table 9

Three Dimensional Repeated Measures Design Repetition on the C Dimension for Heart Rate during Mirror Tracing--Days 1 and 2

Source	df	Day 1 MS	Day 1 F	Day 2 MS	Day 2 F
Among Subjects					
Order	1	112.31	.38	83.27	.31
Sex	2	89.40	.30	225.63	.84
Order x Sex	1	1.92	.01	75.46	.28
Error	24	249.00		268.01	
Within Subjects					
Room	2	11.49	1.70	.49	.05
Room x Order	4	5.70	.85	14.99	1.69
Room x Sex	2	29.49	4.37*	11.78	1.33
Room x Sex x Order	4	10.29	1.53	23.30	2.62**
Error	48	6.74		8.88	

*$p < .02$

**$p < .05$

Descriptive data on the mean heart rate during mirror tracing (Day 2) are presented in Table 10. A study of the table revealed that males and females in Group 1 exhibited a lower mean heart rate score than Groups 2 and 3 in each of the colored rooms. Heterogeneity of the groups was indicated by the large standard deviations.

Table 10

Description of the Heart Rate Scores during Mirror Tracing--Day 2

Subject Sex and Group	Preferred *M*	Preferred *SD*	Nonpreferred *M*	Nonpreferred *SD*	Multicolored *M*	Multicolored *SD*
Group 1						
Males	94.0	7.4	90.2	7.9	94.3	8.3
Females	93.7	7.1	92.9	8.0	91.2	7.3
Group 2						
Males	90.4	12.1	94.9	12.3	93.9	12.9
Females	99.9	9.3	97.1	8.0	99.2	8.5
Group 3						
Males	93.4	9.9	93.7	8.0	93.5	10.6
Females	95.7	11.4	99.6	11.6	96.5	11.6

Summaries of the analysis on mean heart rate during the second day of performance on the mirror tracing task are presented in Table 9. Examination of the table shows non-significant main effects for order and sex as well as no significance in the order-by-sex interaction. Further inspection revealed no significant difference in the main effect of room or the room-by-order and room-by-sex interaction effects. The room-by-order-by-sex interaction was significant beyond the .05 level. This indicates the trend in heart rate across the colored rooms and their order of presentation was not the same for the male and female children in each group.

Pursuit Rotor

Descriptive data regarding the heart rate scores (Day 1) during performance on the pursuit rotor task are presented in Table 11. Inspection of the table showed that Group 2 experienced a higher heart rate than Groups 1 and 3 in the preferred colored and multicolored rooms with a mean value of 104.7 and 107.4, and 103.1 and 107.5 bpm, respectively. Group 1 exhibited the highest heart rate in the nonpreferred room with a mean rate of 100.7 and 107.1 bpm. The large standard deviations of the three groups indicated subject variability.

Table 11

Description of the Heart Rate Scores during Pursuit Rotor Performance--Day 1

Subject Sex and Group	Preferred *M*	Preferred *SD*	Nonpreferred *M*	Nonpreferred *SD*	Multicolored *M*	Multicolored *SD*
Group 1						
Males	101.0	5.9	100.7	8.1	103.4	9.6
Females	105.2	8.2	107.1	7.2	106.7	8.3
Group 2						
Males	104.7	14.1	102.7	7.6	103.1	12.6
Females	107.4	8.9	103.9	9.4	107.5	8.1
Group 3						
Males	101.4	11.5	102.1	11.2	99.3	11.2
Females	100.7	14.5	96.9	13.4	101.3	12.7

Table 12 presents the analysis examining the effects of room color on heart rate during the first day of pursuit rotor performance. The nonrepeated dimension of the analysis revealed nonsignificant main effects for room and sex, in addition to a nonsignificant order-by-sex interaction effect. The repeated dimension failed to reveal a significant main effect of room or any significant interaction effects.

Table 12

Three Dimensional Repeated Measures Design Repetition on the C Dimension for Heart Rate during Pursuit Rotor Task--Days 1 and 2

Source	df	Day 1 MS	Day 1 F	Day 2 MS	Day 2 F
Among Subjects					
Order	2	179.89	.59	151.80	.48
Sex	1	91.41	.30	454.73	1.44
Order x Sex	2	69.87	.23	22.91	.07
Error	24	305.11		315.70	
Within Subjects					
Room	2	15.65	1.40	12.62	.78
Room x Order	4	10.05	.90	15.71	.97
Room x Sex	2	10.75	.96	18.52	1.14
Room x Order x Sex	4	16.63	1.49	25.59	1.58
Error	48	11.15		16.18	

The means and standard deviations of the heart rate scores during the second day of pursuit rotor performance are presented in Table 13. A study of the table revealed the mean heart rate to be higher for Group 2 than for Groups 1 and 3 in each of the colored rooms. Subject heterogeneity was indicated by the large standard deviations.

Table 13

Description of the Heart Rate Scores during Pursuit Rotor Performance--Day 2

Subject Sex and Group	Preferred M	Preferred SD	Nonpreferred M	Nonpreferred SD	Multicolored M	Multicolored SD
Group 1						
Males	97.7	9.3	95.6	10.1	99.7	8.3
Females	101.7	9.8	100.9	11.6	100.8	7.7
Group 2						
Males	101.2	14.4	98.3	16.0	101.2	15.7
Females	106.2	6.5	106.7	8.0	107.3	7.8
Group 3						
Males	98.6	10.8	99.4	7.6	96.5	10.3
Females	97.7	7.5	102.8	10.6	104.6	14.7

Analysis of the heart rate scores during the second day of pursuit rotor performance is presented in Table 12. Nonsignificant main effects of both order and sex in addition to the nonsignificant order-by-sex interaction effect were found in the nonrepeated dimension of the analysis. Inspection of the within subject dimension failed to reveal a significant main effect of room or any significant interaction effects.

Heart Rate and Motor Performance

The Pearson Product-Moment correlational technique was implemented in this study to determine if a relationship existed between heart rate scores and motor performance scores. Table 14 presents the findings of this analysis. An examination of the table revealed that very little relationship existed between the variables of heart rate and motor performance scores for males and females.

Table 14

Relationship (r) between Heart Rate Scores and Motor Performance Scores

Source	Males	Females
Heart Rate-Mirror Tracing Performance Scores	.30	.10
Heart Rate-Mirror Tracing Learning Scores	.02	.25
Heart Rate-Pursuit Rotor Performance Scores	.20	.19
Heart Rate-Pursuit Rotor Learning Scores	.02	.13

Summary of Results of Heart Rate Analysis

Significant changes in the intensity of arousal, as measured by heart rate, were not apparent as a result of room color during motor skill performance. No significant differences were found between males and females in mean heart rate during learning and performance on either task.

Significant differences in the room-by-sex interaction during the first day of mirror tracing indicated variability in heart rate between males and females in each colored room because of order of presentation. The room-by-order-by-sex interaction for the second day of mirror tracing also was found to be significant. This finding indicated the trend in heart rate and their order of presentation was not the same for the male and female children in the colored rooms. No significant room-by-order interactions existed during either day of performance on the pursuit rotor task. This finding may possibly indicate that the variability in heart rate was a function of the task or order of task performance rather than room color.

Debriefing Interview

The purpose of the debriefing interview was to ascertain subjective impressions and feelings about the testing environment from the male and female children after the experiment had been completed. Analysis of the responses are presented in Tables 15, 16, and 17. The tables present the percentages of the male and female selections to each question.

Table 15

Percentage Description to Questions 1 through 6 on the Debriefing Interview

Question	Preferred Male	Preferred Female	Nonpreferred Male	Nonpreferred Female	Multicolored Male	Multicolored Female
1. Room liked best	57	47	29	33	14	20
2. Room liked least	21	21	50	48	29	41
3. Room best scores in	43	27	21	40	36	33
4. Room worst scores in	21.5	46	57	31	21.5	23
5. Room color liked best	73	80	13	0	13	20
6. Room color least liked	6	6.5	57	87	27	6.5

Summaries of the analysis to questions 1 through 6 from the debriefing interview are presented in Table 16. The majority (57%) of the male fourth- and fifth-grade children liked the preferred colored testing room best, 50% liked the nonpreferred colored testing room least. They thought their best scores were made in the preferred colored room (43%) and worst scores were made in the nonpreferred colored room (57%). Seventy-three percent of the males liked the color of the preferred colored room the best, 67% liked the color of the nonpreferred colored room the least.

Females liked the preferred colored testing room the best (47%) and the nonpreferred colored testing room the least (48%). An interesting note was that the multicolored room received 41% of the responses for the "least liked" testing room. The female children felt they made their best scores (40%) in the nonpreferred colored room and made their worst scores (46%) in the preferred colored room. Eighty percent of the female children liked the color of the preferred colored room the best, 87% liked the color of the nonpreferred colored room the least. This finding was similar to the males. In conclusion, male and female color preferences do not affect motor skill learning or performance.

Summaries of the analysis from questions 7 through 9 from the debriefing interview are presented in Table 16. The table revealed that 86% of the male children felt "good" in their preferred colored room. Fifty-three percent of the males felt "good" in the nonpreferred colored room while 47% felt "bad" in the same room. In the multicolored room, the majority (77%) of the male children felt "good". In the third category, other, responses (23%) to the multicolored room were: "comfortable", "shaky", and "did not belong in there".

Table 16

Percentage Description to Questions 7 through 9 on the Debriefing Interview

Question	Good		Not Good		Other	
	Male	Female	Male	Female	Male	Female
7. How did you feel in Rm 1? (Preferred)	86	73	0	0	14	27
8. How did you feel in Rm 2? (Nonpreferred)	53	36	47	29	0	35
9. How did you feel in Rm 3? (Multicolored)	77	72	0	0	23	28

Examination of the female children's response to their feeling in the preferred colored room showed 73% felt "good" while 27% felt either "nervous", "radiant", "happy", or "relaxed" in the same room. Mixed responses were received to question 8. Thirty-six percent of the females felt "good", 29% felt "not good", and 35% felt "confident", "relaxed", "tired", or "nervous" in the nonpreferred colored room. None of the females, like the males, felt "not good" in the multicolored room; 77% reported "good" feelings and 28% felt "excited", "happy", "relaxed", or "tired".

In response to question 10, Table 17, the majority (73%) of the female children attributed their performance on both tasks to individual "effort"; only 7% attributed their performance to "room color". Mixed responses were received by the male children to this question. Twenty-five percent attributed their motor performance scores to "ability", 38% to "effort", 19% to "room color", and 7% to the "investigators".

Table 17

Percentage Description to Question 10 on the Debriefing Interview

Question	Ability		Effort		Room Color		Investigator	
	Male	Female	Male	Female	Male	Female	Male	Female
10. What do you think helped you the most while you practiced in the rooms?	25	7	38	73	19	7	7	13

Summary of Results of Debriefing Interview Analysis

Generally, the male and female children liked the preferred colored room and did not like the nonpreferred colored room. Males felt they had their best scores in the nonpreferred colored room. Basically, both sexes felt good in the preferred colored and multicolored rooms; no responses were recorded in the "not good" category for the two rooms. Slightly over half of the males reported good feelings in the nonpreferred colored room, the remaining responses were in the "not good" category. The females had mixed feelings about the nonpreferred room. The majority of both the male and female children perceived something (ability, effort, investigator) other than room color as attributing to their success during motor performance in the testing environment. Overall, the stated feelings about and preferences of color were consistent between the male and female children.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

The purpose of this investigation was to determine the effect of room color on motor skill learning and performance. The specific problem was to determine the effects of preferred colored, nonpreferred colored, and multicolored rooms upon the learning and performance scores of elementary school children in a mirror tracing and pursuit rotor task.

Although children's motor skill learning and performance has been the target of investigation for many years, only recently has research been conducted on the effects of color as it relates to motor skill learning and performance. Since children are constantly bombarded with color in their environment, it seemed essential that this area be explored.

The review of literature was limited to those studies related to the discussion of color and arousal and their effect on the ability of children to learn and to perform complex motor skills. Results generally have indicated that color stimuli may produce an arousal state within the individual that could affect motor skill performance. Study in this area is still the target of investigators because the findings are inconclusive.

Subjects of the study were 15 male and 15 female fourth- and fifth-grade volunteers from Frank Borman Elementary School in Denton, Texas. All of the subjects performed two motor tasks in a preferred colored, nonpreferred colored, and a multicolored room. The testing rooms were located in Room B of Denia Recreation Center, Denton, Texas.

Tasks utilized to measure learning and performance were the pursuit rotor and mirror tracing devices. Heart rate was monitored throughout the treatment period as an indicant of arousal. A debriefing interview was administered to the subjects immediately after all motor testing was completed.

Permission to utilize subjects was granted by the Texas Woman's University Human Research Review Committe, the Principal of Frank Borman Elementary School, the Denton Independent School District, and the Director of Denia Recreation Center. Permission also was obtained from parents of all volunteers in the study.

Two pretest meetings were conducted 3 and 4 weeks prior to the motor testing sessions. In the first meeting, the subjects were administered the color preference questionnaire and the MAS. Only the color preference questionnaire was administered to the subjects at the second meeting. Thirty of the subjects who had completed the MAS and had consistent color responses on both color preference questionnaires were randomly selected for the study. All subjects selected were required to pass within a range of established criteria a test of color discrimination (Ishihara's Test).

Following the pretest meetings, the subjects selected for the study were randomly assigned to one of three experimental groups and received treatment in the following order: Group 1 was tested in the preferred colored room, nonpreferred colored room, and then the multicolored room, Group 2 was tested in the nonpreferred colored room, multicolored room, and then the preferred colored room, and Group 3 was tested in the multicolored room, preferred colored room, and then the nonpreferred colored room.

All subjects in the three groups performed the two motor tasks on two different days, Monday and Wednesday or Tuesday and Thursday. Six trials on the mirror tracing task were performed first and six trials on the pursuit rotor task were performed second in each colored room during each testing session. Heart rate was continually monitored throughout both experimental periods. Upon completion of the motor tasks on the second day of treatment, the debriefing interview was administered.

Motor performance scores (Day 1) were analyzed as performance scores and motor performance scores (Day 2) were treated as learning scores. The collected data were subjected to a three dimensional repeated measures design (Lindquist Type III) with repetition on the C (room) dimension. This was applied to each hypothesis. The Tukey test was applied to main and interaction effects to determine which means differed significantly.

Summary of the Findings

The findings of this investigation are summarized below.

With reference to performance scores:

1. Mirror tracing and pursuit rotor performance became increasingly better with practice.

2. Room color did not affect mirror tracing and pursuit rotor performance scores.

3. Males and females were equal in motor skill ability on these tasks.

4. No specific order of testing was more beneficial or detrimental to performance on the motor tasks.

With reference to learning scores:

1. Males experienced greater learning than females on the pursuit rotor task; however, this finding was not attributed to room color effects.

2. Very little change in performance was evident in

the mirror tracing scores.

3. Group 1 had higher learning scores than Groups 2 and 3 on the mirror tracing task; however, final ability was the same for the three groups.

4. Room color did not affect pursuit rotor learning scores.

5. Males and females had similar mirror tracing learning scores.

6. No specific order of testing was more beneficial or detrimental to learning the pursuit rotor task.

With reference to mean heart rate scores:

1. There was no relationship between heart rate and the learning and performance scores derived from the mirror tracing and pursuit rotor tasks.

2. Variability in heart rate between colored rooms was evident for the groups during learning and performance of the mirror tracing task; however, no consistent pattern of variability occurred between rooms or sex.

3. No differences in heart rate were apparent between males and females during motor skill learning or performance.

4. Variability in heart rate between the colored rooms was not apparent during the pursuit rotor task.

With reference to the debriefing interview:

1. Males and females liked the testing room which was painted in the color of their stated preference.

2. Males and females did not like the testing room which was painted in their stated nonpreferred color.

3. Males thought they performed best in the preferred colored room.

4. Females felt they performed best in the nonpreferred colored room.

5. Some males and females liked the color of the preferred colored room.

6. Some males and females did not like the color of the nonpreferred colored room.

7. Some males and females felt good in the preferred colored and nonpreferred colored rooms.

8. Feelings in the nonpreferred room were mixed (both good and bad) for both males and females.

9. Males attributed their success in motor performance to either ability or effort.

10. Females attributed their success in motor performance to effort.

Results of the data analysis and interpretation led this investigator to support or fail to support the following hypotheses:

1. There is no significant difference in the mean

learning and performance scores of boys and girls on two complex motor tasks among groups exposed to preferred colored, nonpreferred colored, and multicolored rooms. Supported. (Tables 2, 5, 6)

2. There is no significant difference in the mean heart rate of boys and girls on two complex motor tasks among groups exposed to the colored rooms. Supported. (Tables 9, 12)

3. There is no interaction between the factors of order, sex, and room color when considering heart rate and learning and performance scores. Failed to support. (Tables 2, 5, 9, 12)

Conclusions

Based on the findings of this investigation, the following conclusions appear justified:

1. Room color, whether preferred or nonpreferred, is not detrimental to children's learning and performance of motor tasks such as those utilized in this study. Although they expressed feelings of "nervousness", "tiredness", and "not belonging" while in the nonpreferred colored and multicolored rooms, these perceived feelings did not interfere with the attainment of skill on the tasks. Elementary Educators should attempt to brighten their classroom/gymnasium by utilizing primary colors. These colors may not enhance

motor skill performance, but previous research indicates the morale of the children may be improved.

2. Arousal state, as reflected by heart rate, has no appreciable effect on the learning and performance scores of the fourth- and fifth-grade boys and girls on the two motor tasks. The feelings associated with the room colors, therefore, did not noticeably affect the children's heart rate.

3. Children exhibit variation in heart rate across rooms during learning and performance of the mirror tracing task; this finding is not evident during the pursuit rotor task. The motivating condition, therefore, appears to result from the task or order of task performance and not the color stimuli.

4. Variations in learning and performance scores on motor tasks in colored rooms is evident for both male and female children.

Recommendations for Future Studies

Based on the results of this investigation, the following recommendations for future study are presented:

1. A replication of the study utilizing tasks that require cognitive learning and performance.

2. A replication of the study using younger age children.

3. A replication of the present study utilizing galvanic skin response as the technique for measurement of arousal.

4. A replication of the study utilizing different motor tasks.

5. A study to determine the effects of neutral colored, multicolored, and nonpreferred colored rooms on initial learning and performance of complex skills.

6. A study to determine the effects of room color when introduced after initial learning has begun.

APPENDIX A

INSTRUMENTS

ROOM COLOR-PREFERENCE QUESTIONNAIRE

1. If you had your choice, which color room would you like to work in?

   Write number __________

2. If you had your choice, which color room would you least like to work in?

   Write number __________

CHILDREN'S MANIFEST ANXIETY SCALE

INSTRUCTIONS: Read each question carefully. Put a circle around the word YES if you think it is true about you. Put a circle around the word NO if you think it is not true about you.

YES NO 1. It is hard for me to keep my mind on anything.

YES NO 2. I get nervous when someone watches me work.

YES NO 3. I feel I have to be best in everything.

YES NO 4. I blush easily.

YES NO 5. I notice my heart beats very fast sometimes.

YES NO 6. At times I feel like shouting.

YES NO 7. I wish I could be very far from here.

YES NO 8. Others seem to do things easier than I can.

YES NO 9. I am secretly afraid of a lot of things.

YES NO 10. I feel that others do not like the way I do things.

YES NO 11. I feel alone even when ther are people around me.

YES NO 12. I have trouble making up my mind.

YES NO 13. I get nervous when things do not go the right way for me.

YES NO 14. I worry most of the time.

YES NO 15. I worry about what my parents will say to me.

YES NO 16. Often I have trouble getting my breath.

YES NO 17. I get angry easily.

YES NO 18. My hands feel sweaty.

YES NO 19. I have to go to the toilet more than most people.

YES NO 20. Other children are happier than I.

YES NO 21. I have trouble swallowing.

YES NO 22. I have worries about things that did not really make any difference later.

YES NO 23. My feelings get hurt easily.

YES NO 24. I worry about what other people think about me.

YES NO 25. I worry about doing the right things.

YES NO 26. I worry about what is going to happen.

YES NO 27. It is hard for me to go to sleep at night.

YES NO 28. I worry about how well I am doing in school.

YES NO 29. My feelings get hurt easily when I am scolded.

YES NO 30. I often get lonesome when I am with people.

YES NO 31. I feel someone will tell me I do things the wrong way.

YES NO 32. I am afraid of the dark.

YES NO 33. It is hard for me to keep my mind on my school work.

YES NO 34. Often I feel sick in my stomach.

YES NO 35. I worry when I go to bed at night.

YES NO 36. I often do things I wish I had never done.

YES NO 37. I get headaches.

YES NO 38. I often worry about what could happen to my parents.

YES NO 39. I get tired easily.

YES NO 40. I have bad dreams.

YES NO 41. I am nervous.

YES NO 42. I often worry about something bad happening to me.

DEBRIEFING INTERVIEW

1. Which testing room did you like the best, room 1 - 2 - 3?

   Why?

2. Which testing room did you like the least, room 1 - 2 - 3?

   Why?

3. Which room do you think you had your best scores in, room 1 - 2 - 3?

   Why?

4. Which room do you think you had your worst scores in, room 1 - 2 - 3?

   Why?

5. In which room did you like the room color best, 1 - 2 - 3?

   Why?

6. In which room did you like the room color the least, 1 - 2 - 3?

   Why?

7. How did you feel in room 1?
8. How did you feel in room 2?
9. How did you feel in room 3?
10. What do you think helped you the most while you

practiced in the rooms - ability - effort - room color - investigator?

APPENDIX B

CONSENT FORMS

November 5, 1980

Dear Parent:

I am a doctoral student at Texas Woman's University. My interest in how children learn motor skills has led to my present study. My study investigates room color and motor performance.

Your child is being invited to participate in this study. He/she will have fun taking the tests and will be providing information which we hope will be of value to many children. The tests will involve two motor tasks (tracing a star figure while looking into a mirror and following a light circling a triangle) and the children's heart rate will be monitored during practice. The Children's Manifest Anxiety Scale (a paper-pencil test), a Color-Preference questionnaire, and a personal interview with me will comprise what your child will be asked to do. Your child will be tested in Room A at Denia Recreation Center on two separate days, approximately 30 minutes each day. Teresa Milam, Director of the Center, and Mr. Estes, Principal of Frank Borman Elementary School, have given permission for me to test the children during their physical education class period and after school from 3:30 to 6:00 p.m.

If for any reason the child does not wish to contine in the group, he/she is free to leave the testing room immediately. Should you desire to know your child's scores or the results of the study, I will be glad to make them available to you. If you are willing to let your child participate in the study, please sign the attached consent form and return it to Denia Recreation Center or to Mr. Estes' office. If you have any questions, please contact me by telephone, 566-3188. Your cooperation will be greatly appreciated.

____

Cindy Bross
Texas Woman's University

____

Teresa Milam
Denia Recreation Center

CONSENT FORM

_________________________________ may take part in the test to
(Child's name)

study motor performance of elementary school children. I understand that the element of physical or psychological injury to my child is negligible, but in the event of an injury resulting from participation in the research, no medical service or compensation will be provided by Texas Woman's University.

____
(Child's signature)

____
(Parent's signature)

TEXAS WOMAN'S UNIVERSITY

DEPARTMENT OF PHYSICAL EDUCATION

Agency Permission for Conducting Study

The Denia Recreation Center, Teresa Milam - Director
(Institution or agency)

Grants to Cynthia J. Bross
(student)

enrolled in a program of physical education leading to a Doctor of Philosophy degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

"The Effects of Room Color on Learning and Performance of Two Complex Motor Tasks by Fourth and Fifth Grade Students"

10/22/80
Date

Teresa Milam
Signature of Agency Personnel

Cynthia J. Bross
Signature of Student

Bettye Myers
Faculty Advisor

TEXAS WOMAN'S UNIVERSITY

DEPARTMENT OF PHYSICAL EDUCATION

Agency Permission for Conducting Study

The Denton Independent School District
(Institution or agency)

Grants to Cynthia J. Bross
(student)

enrolled in a program of physical education leading to a Doctor of Philosophy degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

"The Effects of Room Color on Learning and Performance of Two Complex Motor Tasks by Fourth and Fifth Grade Students"

10/22/80
Date

Roy L. Chancellor
Signature of Agency Personnel

Cynthia J. Bross
Signature of Student

[illegible signature]
Faculty Advisor

TEXAS WOMAN'S UNIVERSITY

DEPARTMENT OF PHYSICAL EDUCATION

Agency Permission for Conducting Study

The Frank Borman Elementary School, Mr. Estes - Principal

Grants to Cynthia J. Bross

enrolled in a program of physical education leading to a Doctor of Philosophy degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

"The Effects of Room Color on Learning and Performance of Two Complex Motor Tasks by Fourth and Fifth Grade Students"

10/22/80
Date

Robert M. Estes
Signature of Agency Personnel

Cynthia J Bross
Signature of Student

Betty Myers
Faculty Advisor

TEXAS WOMAN'S UNIVERSITY
Box 23717 TWU Station
Denton, Texas 76204

HUMAN SUBJECTS REVIEW COMMITTEE

Name of Investigator: ~~Cynthia J. Bross~~ Center: Denton

Address: 425 Fulton #207 Date: October 31, 1980

Denton, TX 76201

Dear Cynthia J. Bross

Your study entitled The Effects of Room Color on Learning and Performance of Two Complex Motor Tasks of Fourth and Fifth Grade Students has been reviewed by a committee of the Human Subjects Review Committee and it appears to meet our requirements in regard to protection of the individual's rights.

Please be reminded that both the University and the Department of Health, Education, and Welfare regulations typically require that signatures indicating informed consent be obtained from all human subjects in your studies. These are to be filed with the Human Subjects Review Committee. Any exception to this requirement is noted below. Furthermore, according to DHEW regulations, another review by the Committee is required if your project changes.

Any special provisions pertaining to your study are noted below:

_____ Add to informed consent form: No medical service or compensation is provided to subjects by the University as a result of injury from participation in research.

_____ Add to informed consent form: I UNDERSTAND THAT THE RETURN OF MY QUESTIONNAIRE CONSTITUTES MY INFORMED CONSENT TO ACT AS A SUBJECT IN THIS RESEARCH.

_____ The filing of signatures of subjects with the Human Subjects Review Committee is not required.

__x__ Other: Specify on consent form that subjects may withdraw at any time. Also, Children over the age of 6 years must also sign the consent forms.

_____ No special provisions apply.

cc: Graduate School
Project Director
Director of School or
Chairman of Department

Sincerely,

Marilyn Hinson

Chairman, Human Subjects
Review Committee

at Denton

APPENDIX C

SCORE SHEETS

MIRROR TRACING SCORE SHEET

Name ______________________ Group ______________________

ROOM 1

	ER	RUN	To	HR
T1	____	____	____	
T2	____	____	____	
T3	____	____	____	
T4	____	____	____	
T5	____	____	____	
T6	____	____	____	
To	____	____	____	____
$\bar{X}$	____	____	____	____

ROOM 2

	ER	RUN	To	HR
T1	____	____	____	
T2	____	____	____	
T3	____	____	____	
T4	____	____	____	
T5	____	____	____	
T6	____	____	____	
To	____	____	____	____
$\bar{X}$	____	____	____	____

ROOM 3

T1	____	____	____	
T2	____	____	____	
T3	____	____	____	
T4	____	____	____	
T5	____	____	____	
T6	____	____	____	
To	____	____	____	____
$\bar{X}$	____	____	____	____

ROOM 1

T1	____	____	____	
T2	____	____	____	
T3	____	____	____	
T4	____	____	____	
T5	____	____	____	
T6	____	____	____	
To	____	____	____	____
$\bar{X}$	____	____	____	____

<u>ROOM 2</u>

	ER	RUN	To	HR
T1	______	______	______	
T2	______	______	______	
T3	______	______	______	
T4	______	______	______	
T5	______	______	______	
T6	______	______	______	
To	______	______	______	______
$\bar{X}$	______	______	______	______

<u>ROOM 3</u>

	ER	RUN	To	HR
T1	______	______	______	
T2	______	______	______	
T3	______	______	______	
T4	______	______	______	
T5	______	______	______	
T6	______	______	______	
To	______	______	______	______
$\bar{X}$	______	______	______	______

PURSUIT ROTOR SCORE SHEET

Name ______________________ Group ______________________

	ROOM 1 Time	ROOM 1 HR	ROOM 2 Time	ROOM 2 HR	ROOM 3 Time	ROOM 3 HR
T1	______		______		______	
T2	______		______		______	
T3	______		______		______	
T4	______		______		______	
T5	______		______		______	
T6	______		______		______	
To	______	______	______	______	______	______
$\bar{X}$	______	______	______	______	______	______

	ROOM 1 Time	ROOM 1 HR	ROOM 2 Time	ROOM 2 HR	ROOM 3 Time	ROOM 3 HR
T1	______		______		______	
T2	______		______		______	
T3	______		______		______	
T4	______		______		______	
T5	______		______		______	
T6	______		______		______	
To	______	______	______	______	______	______
$\bar{X}$	______	______	______	______	______	______

APPENDIX D

RAW DATA

MANIFEST ANXIETY SCORE AND COLOR PREFERENCE

Subject & Sex	MAS Score	Preferred Color	Nonpreferred Color
1,F	17	Light Blue	Black
2,F	22	Yellow	Black
3,F	24	Light Blue	Black
4,F	22	Red	Black
5,F	18	Yellow	Black
6,M	21	Red	Black
7,M	19	Light Blue	Black
8,M	16	Yellow	Black
9,M	21	Red	Black
10,M	16	Blue	Green
11,F	13	Light Blue	Black
12,F	24	Light Blue	Black
13,F	19	Blue	Black
14,F	11	Green	Black
15,F	16	Yellow	Black
16,M	12	Green	Black
17,M	24	Light Blue	Black
18,M	18	Light Blue	Pink
19,M	24	Dark Yellow	Black
20,M	20	Green	Black
21,F	23	Light Blue	Black
22,F	18	Blue	Black
23,F	11	Red	Black
24,F	17	Blue	Black
25,F	11	Yellow	Black
26,M	12	Light Blue	Black
27,M	10	Green	Pink

MANIFEST ANXIETY SCORE AND COLOR PREFERENCE CON'T.

Subject & Sex	MAS Score	Preferred Color	Nonpreferred Color
28,M	16	Light Blue	Black
29,M	23	Light Blue	Black
30,M	23	Green	Black

RAW SCORES--MIRROR TRACING

Group I--Day 1	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	30.3	27.0	28.0	4.9	36.8	57.0	24.1	43.5	22.5
	22.2	30.7	34.1	21.3	17.7	29.5	24.3	23.1	18.3
2,F	223.1	92.9	58.4	79.3	26.0	18.2	25.9	10.7	9.7
	51.3	31.0	26.0	51.1	61.7	17.6	12.1	10.8	13.2
3,F	173.7	156.9	130.0	47.3	54.0	66.4	42.5	40.7	43.6
	68.3	51.7	44.9	49.2	57.6	50.7	50.1	39.7	42.6
4,F	85.1	68.9	47.6	36.3	30.6	33.7	34.7	32.1	30.9
	42.6	39.5	30.9	17.3	16.0	21.9	16.1	19.5	15.3
5,F	49.0	43.7	41.4	37.0	22.9	32.1	34.4	30.3	36.1
	40.5	46.1	36.3	34.1	32.8	27.7	34.6	21.0	19.6
6,M	88.3	68.5	35.5	17.9	15.1	11.8	8.2	11.6	9.3
	17.6	19.0	19.8	12.5	10.2	11.5	10.0	9.4	6.9
7,M	132.8	30.9	21.6	12.6	10.4	10.4	10.3	10.5	6.1
	14.5	20.9	13.2	6.2	9.4	7.2	9.6	8.7	9.0
8,M	177.3	51.7	52.9	20.9	11.0	13.4	13.7	8.9	6.8
	49.7	33.0	29.2	10.6	13.5	13.4	8.5	8.6	7.9
9,M	33.6	53.7	34.8	38.6	19.3	15.9	16.3	41.7	34.9
	31.0	58.1	35.2	15.1	15.6	13.2	58.3	49.2	32.5
10,M	182.7	236.4	55.7	13.7	14.5	13.9	8.3	8.4	8.7
	33.7	12.6	32.4	10.4	12.4	8.9	6.8	6.6	6.7

RAW SCORES--MIRROR TRACING

Group I--Day 2	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	20.8	24.0	20.1	14.3	30.9	50.5	15.6	28.3	14.2
	18.9	14.0	15.9	18.7	33.3	14.1	17.7	14.0	16.6
2,F	15.6	13.2	9.0	8.2	9.9	8.5	6.4	6.4	6.8
	7.3	8.5	8.5	7.2	5.9	4.5	6.5	5.5	7.6
3,F	45.6	28.7	32.5	30.5	19.8	24.4	25.9	39.1	38.6
	34.1	30.9	27.3	24.0	26.1	28.1	25.2	24.8	31.8
4,F	22.5	18.7	14.9	13.7	14.7	16.0	11.5	12.8	22.1
	14.1	14.8	12.3	15.8	17.9	11.3	19.1	20.3	18.2
5,F	23.2	19.4	21.8	16.4	15.9	16.9	15.7	16.8	18.4
	16.3	15.2	15.0	15.3	16.8	14.7	13.9	14.3	11.7
6,M	6.5	8.2	19.5	5.2	7.0	5.2	3.0	3.2	3.3
	18.5	10.3	17.8	4.6	6.3	3.8	4.3	3.8	7.5
7,M	10.0	8.2	6.3	9.3	6.0	5.8	9.3	5.2	5.5
	5.5	5.0	4.6	4.6	6.3	6.3	5.5	5.1	5.1
8,M	9.5	10.2	8.4	6.2	5.7	7.2	5.9	6.4	5.5
	7.1	9.5	9.0	7.0	5.8	5.5	6.2	5.6	6.0
9,M	31.1	20.2	24.2	18.5	36.2	17.1	18.1	18.4	14.7
	35.8	17.7	15.2	43.8	17.2	14.2	11.2	11.3	9.1
10,M	7.9	8.8	5.0	4.8	4.0	3.7	4.8	3.6	3.5
	5.3	4.4	4.7	3.4	4.2	5.2	4.0	5.0	5.1

RAW SCORES--MIRROR TRACING

Group II--Day 1	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	16.8	14.6	12.9	9.2	6.7	5.8	102.1	60.1	41.7
	14.3	13.8	9.4	7.0	6.4	6.2	46.6	23.2	14.7
2,F	13.4	11.7	12.8	9.0	7.2	7.7	29.9	70.8	16.1
	9.2	11.1	12.6	6.0	4.8	4.5	15.4	10.6	13.5
3,F	55.7	43.9	37.3	41.0	31.1	33.1	194.4	87.2	68.2
	39.7	42.5	31.8	29.2	29.6	28.6	74.4	58.8	58.0
4,F	32.4	26.1	35.7	22.6	9.6	12.5	27.5	30.7	21.7
	24.0	21.0	39.5	12.1	8.9	10.4	17.8	33.0	26.5
5,F	40.7	30.7	30.1	30.4	18.6	28.0	49.7	56.1	35.2
	23.6	31.0	30.8	27.1	29.0	27.1	47.3	12.1	36.9
6,M	32.8	29.2	30.3	25.7	30.1	28.5	53.8	31.8	30.3
	30.2	31.8	29.0	22.0	23.7	23.3	26.5	26.5	25.8
7,M	38.0	18.9	14.7	21.0	10.1	11.8	149.3	135.7	24.9
	18.0	13.7	14.3	8.6	12.9	9.8	43.9	17.6	27.7
8,M	24.5	15.3	15.1	11.9	12.8	11.9	53.6	36.3	22.6
	13.1	12.4	15.2	14.7	11.2	11.2	24.4	13.1	13.8
9,M	10.8	8.9	7.9	11.5	9.6	10.7	13.2	19.0	15.1
	4.9	8.6	8.6	6.5	8.5	5.0	9.7	8.7	9.9
10,M	5.3	5.2	3.5	3.6	3.4	2.6	29.9	14.0	9.7
	2.2	4.0	4.6	1.7	3.0	2.8	6.6	7.9	8.7

RAW SCORES--MIRROR TRACING

Group II--Day 2	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	4.4	4.8	5.8	5.0	4.3	4.8	10.0	7.5	12.5
	4.6	5.5	4.9	4.1	5.3	3.8	3.4	3.8	10.3
2,F	8.2	14.5	9.7	14.8	10.2	12.5	6.0	4.4	10.1
	10.6	8.4	14.7	10.3	9.2	10.2	8.0	8.8	10.8
3,F	25.6	24.8	20.9	28.0	28.0	26.6	22.9	24.7	28.1
	21.6	23.6	23.5	22.9	24.2	20.8	25.6	21.9	23.7
4,F	9.4	8.2	6.5	5.6	5.6	6.1	12.2	12.1	10.0
	7.1	13.3	6.1	6.3	10.0	26.1	7.7	9.2	7.5
5,F	9.3	10.7	10.1	8.6	7.8	9.4	22.5	10.9	14.6
	9.1	9.2	7.8	6.7	7.0	9.4	17.3	9.4	12.7
6,M	14.3	12.7	13.3	10.2	11.4	10.0	17.0	18.0	16.8
	13.2	15.8	13.8	13.3	13.8	14.5	19.2	15.0	14.5
7,M	6.9	6.5	7.3	6.8	6.2	6.0	9.7	10.3	8.7
	6.5	5.0	7.0	6.7	5.3	5.6	7.7	8.5	9.7
8,M	8.3	9.9	8.0	8.7	7.3	8.6	14.1	11.2	10.1
	9.3	9.0	9.3	5.9	8.3	8.1	10.3	8.7	7.4
9,M	5.2	6.1	5.8	6.8	5.6	6.7	7.4	7.2	7.1
	6.2	6.2	5.6	4.9	5.9	5.9	4.8	7.4	5.0
10,M	1.6	2.3	1.0	2.2	1.7	1.4	4.8	3.2	2.9
	2.6	2.3	2.0	2.8	1.9	2.1	2.2	1.9	2.3

RAW SCORES--MIRROR TRACING

Group III--Day 1	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	19.5	29.0	10.3	74.1	22.3	19.4	13.7	13.8	21.5
	10.9	10.4	7.7	20.9	17.5	18.1	21.1	10.0	10.9
2,F	68.3	61.0	52.6	160.2	160.8	83.9	102.1	88.7	73.1
	40.7	41.5	36.2	79.4	65.8	100.0	55.0	50.9	49.1
3,F	9.8	13.4	14.3	50.3	18.4	15.4	13.3	27.1	19.2
	9.2	11.7	8.5	17.1	16.8	14.8	18.8	13.7	9.1
4,F	44.9	34.3	49.9	93.9	61.7	87.3	53.4	36.9	36.9
	33.4	31.8	28.5	53.8	63.7	57.6	44.8	37.5	45.8
5,F	15.1	12.6	8.7	22.8	17.3	6.2	30.4	62.5	12.9
	11.6	8.9	7.4	9.2	20.6	89.6	19.8	10.7	21.1
6,M	43.8	28.3	30.0	46.7	41.5	38.8	55.7	40.8	33.6
	30.6	29.3	21.3	40.2	47.3	50.4	27.9	43.1	74.1
7,M	10.1	23.6	8.4	67.9	41.0	40.7	24.0	12.9	13.0
	10.9	7.9	5.7	32.4	21.2	20.8	22.9	10.3	12.1
8,M	16.2	13.5	13.9	57.6	40.8	34.0	19.5	15.7	16.7
	12.9	13.0	12.9	27.2	35.4	26.2	17.8	16.0	15.2
9,M	11.0	16.3	15.2	32.5	26.3	25.5	20.1	8.6	17.5
	10.1	13.2	13.0	28.9	12.9	13.8	11.8	13.7	10.2
10,M	24.2	24.7	28.1	53.2	35.9	28.2	26.9	28.2	28.1
	24.2	31.6	29.7	34.0	25.2	24.4	26.0	28.7	26.6

RAW SCORES--MIRROR TRACING

Group III--Day 2	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	4.8	5.4	5.5	10.5	7.4	5.6	4.8	5.3	8.7
	4.6	5.4	4.8	5.9	6.3	5.5	5.9	6.7	5.9
2,F	37.2	33.5	35.1	55.0	46.4	47.9	33.5	37.0	30.5
	33.5	31.5	41.2	43.8	37.3	36.9	32.2	29.3	43.7
3,F	9.0	8.4	7.6	13.0	11.5	10.9	8.9	10.0	9.1
	9.4	6.9	9.8	8.2	9.8	8.6	7.0	8.8	9.8
4,F	22.0	21.3	23.4	30.2	25.8	22.8	23.2	24.7	22.8
	16.8	20.6	17.3	22.4	22.3	21.5	22.9	21.6	20.0
5,F	7.9	5.5	4.5	6.3	11.8	4.7	5.7	7.0	9.3
	6.3	6.0	7.0	7.3	4.7	4.0	3.2	4.0	4.6
6,M	20.6	12.9	16.9	42.2	35.2	26.9	23.0	20.8	19.0
	17.2	20.0	13.7	27.6	31.4	28.9	17.9	22.3	20.1
7,M	4.5	4.6	4.3	7.3	12.9	5.1	5.1	7.1	5.1
	4.3	4.9	5.1	5.5	6.4	7.9	5.2	6.0	5.6
8,M	6.2	5.4	5.3	13.0	8.7	9.6	6.7	7.4	6.2
	5.4	6.6	4.5	7.9	8.0	8.9	5.7	6.4	6.6
9,M	11.2	8.9	15.1	13.7	10.4	10.5	12.4	12.7	12.1
	18.7	11.8	11.9	11.5	10.7	21.9	10.3	9.7	10.8
10,M	15.7	13.0	14.8	23.1	22.4	24.6	23.2	23.0	23.3
	13.1	13.4	14.1	19.0	21.8	26.2	16.5	20.8	18.3

RAW SCORES--PURSUIT ROTOR

Group I--Day 1	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	.20	.15	.27	1.47	2.38	1.60	3.86	2.68	4.54
	.63	.56	1.26	2.81	2.45	4.27	4.70	4.15	5.07
2,F	.14	.06	.06	.39	.60	.42	.08	.51	1.12
	.33	.12	.21	.44	.51	.33	.77	.96	.32
3,F	.00	1.36	1.19	.00	2.93	2.34	3.76	.00	4.32
	1.22	2.21	.94	2.52	2.75	3.52	3.51	3.44	2.63
4,F	.00	.52	.88	1.71	.43	.48	.64	.79	.48
	.26	.47	.76	.62	.64	.56	.60	1.32	1.70
5,F	.12	.25	.59	.18	.66	.73	.31	.12	.67
	.25	.52	1.03	.21	.32	.64	1.12	1.74	.77
6,M	.59	1.71	1.96	2.90	2.30	1.74	2.18	1.84	1.35
	1.60	2.37	2.30	1.64	1.10	1.66	1.72	1.47	2.06
7,M	.44	.30	.51	.56	.50	.83	1.78	2.01	1.02
	.39	.61	.25	1.59	1.52	1.62	2.36	2.42	2.81
8,M	1.45	1.45	2.91	3.30	2.03	2.26	3.41	4.85	3.49
	2.34	1.35	1.46	1.30	3.08	5.37	3.17	5.17	3.60
9,M	.15	.07	.15	.54	.77	.35	.15	.53	.30
	.25	.35	.65	.36	.32	.46	.17	.45	.22
10,M	.19	1.80	1.29	1.27	1.37	1.45	1.79	2.64	1.47
	1.18	1.46	1.26	1.53	1.63	1.90	1.20	2.02	2.09

RAW SCORES--PURSUIT ROTOR

Group I--Day 2	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	5.88	5.00	5.12	6.17	5.18	6.37	6.25	6.42	6.90
	4.94	5.60	5.53	5.91	5.64	5.60	7.65	6.53	5.27
2,F	.21	.31	.38	.56	.46	.24	.50	1.58	.57
	.34	.54	.61	.90	.26	.64	.42	.31	.58
3,F	2.54	2.54	3.09	2.99	2.73	3.92	2.65	2.88	2.78
	4.51	2.24	3.21	3.62	3.23	2.19	3.33	4.40	4.06
4,F	.80	1.07	1.71	.98	1.53	1.53	1.78	1.57	2.27
	1.21	1.78	1.41	1.78	1.47	2.45	1.60	1.59	1.01
5,F	.48	1.31	1.73	1.22	1.05	.42	1.00	.63	.50
	1.41	1.58	1.58	1.00	.87	.60	.42	.92	.76
6,M	3.31	4.35	3.36	5.75	3.11	5.47	3.12	3.24	3.32
	3.34	4.41	3.62	3.43	2.80	2.63	2.82	4.62	3.35
7,M	5.72	5.45	6.17	6.77	6.48	5.65	6.45	6.70	6.73
	6.30	4.56	5.44	5.38	6.72	5.18	7.57	7.36	8.03
8,M	4.79	5.83	6.15	5.46	6.35	6.01	6.36	5.63	5.02
	7.35	3.24	6.88	5.13	6.16	5.70	6.02	5.06	4.36
9,M	.12	.22	.26	.32	.17	.27	.40	.31	.13
	.16	.18	.34	.23	.25	.33	.28	.24	.15
10,M	3.11	4.16	3.81	2.28	2.91	3.30	3.47	3.31	4.30
	3.64	4.51	2.63	3.62	3.60	4.16	3.41	3.77	4.22

RAW SCORES--PURSUIT ROTOR

Group II--Day 1	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	1.40	1.54	1.45	2.00	2.08	2.28	.72	1.56	.95
	1.41	1.79	2.43	1.68	1.78	1.85	.65	1.21	1.12
2,F	3.14	4.43	3.40	4.27	3.82	4.75	.77	1.89	2.30
	3.76	2.61	2.99	4.15	5.29	4.95	1.50	1.95	2.87
3,F	1.83	2.26	1.81	2.10	1.47	1.75	.17	.37	.37
	2.50	1.90	2.27	2.48	1.40	3.18	.55	1.86	1.57
4,F	.59	1.19	1.37	.46	.81	.67	.02	.04	.05
	1.81	1.46	1.28	1.64	1.12	1.54	.12	.62	.42
5,F	.96	.84	.22	.60	.75	.61	.27	.60	.59
	1.23	.60	1.12	.26	.62	.80	.96	.40	.46
6,M	3.82	4.02	2.81	3.76	2.62	3.96	.10	1.14	1.94
	2.54	3.12	3.47	3.90	3.63	2.45	1.85	1.86	2.24
7,M	1.93	1.24	2.30	2.26	2.64	2.84	.28	.74	.85
	2.24	2.71	2.70	2.51	1.42	1.73	.59	.50	.77
8,M	1.26	1.00	1.02	.54	.65	.90	.22	.58	.68
	1.25	.84	.85	.87	1.13	.94	.58	1.24	.79
9,M	3.84	2.82	3.67	.00	5.28	4.71	.51	2.67	2.16
	4.46	5.68	5.20	4.58	5.15	6.12	2.57	3.00	4.21
10,M	.42	.28	2.85	3.35	2.34	2.82	.07	.14	.04
	2.80	2.91	1.98	2.06	.00	2.33	.32	.32	.42

RAW DATA--PURSUIT ROTOR

Group II--Day 2	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	2.10	2.31	2.33	3.48	2.18	3.52	2.06	3.10	2.03
	2.65	3.16	3.38	2.43	2.72	1.15	2.55	2.71	2.76
2,F	4.04	7.04	4.72	4.65	6.28	5.94	5.64	4.81	4.67
	6.13	4.80	4.67	3.26	5.22	4.69	6.25	3.26	6.30
3,F	1.52	2.01	2.05	2.36	2.85	2.36	.76	.91	1.22
	1.44	2.43	2.45	1.50	2.94	3.10	1.06	1.14	2.43
4,F	3.34	4.20	3.76	2.24	3.19	3.63	2.30	3.27	3.34
	3.62	4.53	3.07	3.08	2.32	3.80	3.47	3.16	1.85
5,F	1.99	2.31	1.91	2.12	2.67	2.85	3.63	3.28	3.11
	2.08	2.58	2.81	2.97	2.63	3.07	1.84	2.77	2.38
6,M	6.62	7.92	7.20	7.42	8.92	6.73	4.72	4.98	6.68
	7.32	7.90	6.57	9.03	7.85	7.06	6.85	5.98	7.42
7,M	5.59	5.41	4.90	5.61	5.38	4.39	4.27	5.74	4.57
	5.80	7.20	7.09	5.18	5.18	5.20	4.64	5.70	5.46
8,M	5.03	5.42	3.90	6.70	5.68	4.31	4.30	4.33	5.32
	5.32	4.11	6.27	4.00	5.00	5.60	5.03	5.81	6.01
9,M	6.61	5.24	6.62	6.71	8.92	6.45	7.00	6.07	5.17
	6.54	4.32	5.14	6.55	5.12	4.80	4.88	6.74	5.36
10,M	1.00	.53	.63	6.88	8.40	8.66	1.65	.52	1.72
	.75	.56	.35	8.30	7.44	8.24	1.07	.23	.97

RAW SCORES--PURSUIT ROTOR

Group III--Day 1	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	2.66	1.48	3.12	.31	.40	1.01	1.55	3.10	1.66
	1.70	2.01	2.35	.75	.63	1.03	3.52	2.29	3.76
2,F	.42	1.36	.16	.55	.70	.17	.84	.57	1.14
	.52	.25	.97	.46	.80	.60	.59	.67	.41
3,F	2.58	1.58	1.55	.06	.17	.22	1.55	1.74	1.20
	1.79	1.48	2.90	.45	1.51	1.73	1.74	1.75	2.54
4,F	1.96	1.35	2.27	.83	.42	.17	2.52	2.06	1.39
	.75	1.00	.61	.90	1.40	1.86	.98	1.80	1.38
5,F	.58	.78	.57	.03	.35	.55	.31	.74	.87
	.83	.76	.70	.46	.58	.31	.27	.95	.37
6,M	.72	1.34	1.67	.16	.65	.74	.55	.71	.71
	1.63	1.79	1.28	.56	.38	.58	.78	.42	1.06
7,M	3.11	3.97	2.24	.96	1.45	1.88	3.70	2.75	1.99
	2.32	3.77	3.36	1.92	1.97	2.13	1.50	2.47	2.76
8,M	5.76	4.31	3.69	1.27	1.47	2.96	3.70	3.06	4.00
	5.36	6.01	4.17	3.01	2.00	2.04	4.72	4.98	3.67
9,M	2.92	3.08	3.91	1.28	1.90	2.02	4.16	4.32	3.20
	2.49	4.53	4.26	1.73	2.88	2.63	4.35	3.02	3.83
10,M	3.79	2.82	2.56	.08	.06	.35	4.16	3.48	3.35
	3.85	4.07	3.32	1.05	.16	.57	3.87	3.87	3.98

RAW SCORES--PURSUIT ROTOR

Group III--Day 2	Trials								
Subject No. & Sex	Preferred Colored Room			Nonpreferred Colored Room			Multicolored Room		
1,F	5.00	5.67	4.08	3.11	4.17	3.19	4.18	3.86	2.82
	4.13	5.30	4.49	3.82	3.16	2.87	3.12	3.06	3.22
2,F	1.03	1.55	1.56	1.11	.78	1.86	.82	1.51	1.54
	1.60	.66	2.86	1.57	1.47	.70	1.56	1.41	1.17
3,F	4.19	5.00	5.58	3.64	4.45	4.45	3.54	4.91	5.59
	4.33	4.25	4.50	4.34	4.10	4.03	7.35	4.14	5.06
4,F	1.12	1.02	.97	1.44	.97	.63	.88	.98	1.58
	.51	.95	1.16	1.06	1.06	1.00	.63	1.45	1.44
5,F	2.59	1.65	1.91	1.60	2.16	1.70	1.70	2.02	1.64
	1.71	2.05	1.87	2.06	.81	1.69	2.82	1.61	1.76
6,M	4.31	4.62	5.00	2.03	1.75	2.09	4.30	2.90	2.63
	5.06	4.94	4.32	2.79	2.91	2.40	3.06	2.68	2.11
7,M	7.05	6.62	6.07	6.35	6.61	6.40	7.24	5.67	6.68
	6.23	7.03	5.73	5.68	6.40	7.07	6.42	6.31	5.33
8,M	8.27	7.85	5.31	4.11	6.37	5.91	8.56	7.65	6.05
	5.65	6.05	5.78	5.90	6.02	6.52	6.12	7.71	7.67
9,M	4.78	6.32	5.90	6.48	6.87	6.93	4.80	5.52	4.70
	5.22	5.01	5.75	5.44	6.85	5.12	5.90	5.62	6.33
10,M	3.70	5.60	4.80	5.66	4.02	4.64	3.40	6.28	5.02
	2.51	4.68	7.35	2.90	5.38	6.69	5.84	5.44	5.27

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