AN ABSTRACT OF THE THESIS OF

Rebecca A. Ainsworth for the degree of Master of Science in Apparel, Interiors and Merchandising presented on June 9, 1989.

Title: Color in the Work Environment

Abstract approved: Redacted for Privacy

Dr. LoErna Simpson

This study examined the effect that three environmental hues had on subjects' work performance and on mood levels of anxiety, depression, and arousal in an office work environment. Pre-test post- test measurements of differences in work performance and mood levels were used to test twelve hypotheses. Work performance was measured by using an errors-to-words-typed score, and mood levels were measured by use of the Eight State Questionnaire. A total of 45 female subjects ages 18 - 24 were tested individually; 15 in the red/warm hue office environment, 15 in the blue-green/cool environment, and 15 in a white/neutral environment. Subjects completed typical, office related tasks during a minimum of one hour in the office environment. Results of the t-test analyses showed no significant differences between the 3 hue groups for work performance or mood levels of anxiety, depression and arousal. However, mean anxiety level and mean depression level scores were slightly higher on both the pre-test and post-test for subjects working in the office with white/neutral walls than for those subjects working in the identical office space when the walls were red/warm and blue-green/cool.

Color in The Work Environment

By

Rebecca A. Ainsworth

A THESIS
submitted to
Oregon State University

in partial fulfillment of
the requirements for the
degree of
Master of Science

Completed June 9, 1989
Commencement June, 1990

APPROVED:

Redacted for Privacy

Professor of Apparel, Interiors, and Merchandising in charge of major

Redacted for Privacy

Head of department of Apparel, Interiors and Merchandising

Redacted for Privacy

Dean of Graduate School

Date thesis is presented June 9, 1989

ACKNOWLEDGEMENT

I wish to greatfully acknowledge the many hours of time and patience given by Dr. LoErna Simpson, Oregon State University textile science professor. For the past two years she served as a teacher, guide and mentor, assisting me in successfully completing my graduate studies and most importantly in completely this manuscript and the research with which it is backed.

Appreciation for their support, guidance and teaching is also extended to Dr. Sally Francis, Head of the Oregon State University Apparel, Interiors and Merchandising Department; assistant professor of interior design and merchandising, Pamela Evans; Dr. Jeannette Brandt and assistant professor Ray Glass, professors of Family Resource Management. Dr. Leslie Davis is also appreciated for the time and knowledge she shared in helping me think through my research methods, and Mr. Norm Arseneault for his editing assistance.

The following Graduate Thesis Committee members, to whom I extend a very sincere thank you, spent many hours reading and sharing their knowledge of thesis work with me .

Dr. LoErna Simpson, Major Professor

Dr. Jeannette Brandt, Minor Professor

Dr. Vicki Schmall, Graduate School Representative

Asst. Professor Pamela Evans, Dept. Representative

TABLE OF CONTENTS

LIST OF TABLES

COLOR IN THE WORK ENVIRONMENT

CHAPTER I

INTRODUCTION

From earliest recorded history to present day cultures, color has played an important role in a person's life, helping to interpret all things seen and undertaken. Mankind's love of color can be found throughout time in extensive use of color in architecture, dress, and ritual events. Color and decoration have played distinctive roles in religious worship, in denoting social status in life and death, in accentuating royalty, in celebrating the seasons and in giving thanks for nature's bountiful goods. Color theorist Faber Birren wrote, "I do not exaggerate when I say that ancient man surrounded himself with color and in turn was surrounded by it. All civilization since the beginning of man's existence has worshipped the sun, and from the sun came light and color" (Birren, 1978, p. 78). Since the time that Sir Isaac Newton verified the fact that light is composed of color, researchers have been attempting to explain the many effects of light and color on all living species (Hunt, 1987; Paritsis and Stewart, 1983).

In this study the researcher explored the relationship of interior wall hue to an office employee's work performance and mood. Research has shown that human response to color in the environment is a physiological process which ultimately manifests

itself in the form of emotional or physical responses by the individual. Although several studies have investigated human response to color in general environments, very little research has been focused toward a specific work environment.

Color response and preference research has become an increasingly important field in the past four decades as studies have shown the power that color can have over human emotions. Human response to color has been used by people in art, medicine, and business. Color has been used as a stimulus to sell food, household necessities, cars, leisure activities, sex, furniture, houses, and nearly everything else.

It is necessary to understand the human eye in order to investigate color. The three spectrally different types of cones in the retina of the eye determine how a person perceives color. The message received by the retina is sent through the nervous system to the human brain which in turn causes physiological response in the individual (Hunt, 1987). Part of that response is based on the individual's past assimilated information concerning the color, and part is believed to be a result of the color itself. The color seen by an individual is both the visible composition of light as well as the individual's perception of that light. That perception may vary from individual to individual. Research has indicated that infants show a preference for warm colors such as red and yellow, while adults appear to prefer the cooler colors such as blue and green (Adams, 1987). Young children prefer strong, pure, primary colors, appearing to have a natural love of color for the pure fun and enjoyment of color. Adults become less impulsive and more responsive to the subtleness of colors. Research has shown that through education and acquired influences related to color, the human response becomes more sophisticated in its emotional response to color as one

grows older (Zhang and Lin, 1984). This indicates immense possibilities of stimulation use for both the business and service industries.

Color has been perceived as an indicator of psychological wellness, as demonstrated by researchers such as Birren (1978), Lüscher and Rorscharch (as cited in Paritsis and Stewart, 1983), and Ruda (1983). Rhinehart and Engelhorn (1984), on the other hand, have theorized that color can be used to heal and help individuals cope with psychological and physical stresses. This is seemingly supported by research demonstrating physiological response to hues (O'Connell, Harper, and McAndrew, 1985; Jaensch as cited in Paritsis and Stewart, 1983). Other research has been aimed at supporting the theory that color preference and physical reaction are responses based upon an individual's personality, depending on whether an individual has a tendency toward an extroverted or introverted personality type (Birren, 1978; Rhinehart and Engelhorn 1984; Ruda, 1983).

Additionally, color has been demonstrated to have an emotional impact on the human response system. Recent studies have shown the potential for using color to make people more physically and emotionally comfortable in their surroundings (Acking and Küller, 1972; Rhinehart and Engelhart, 1984; Schauss, 1985). Such research supports the theory that color may have the potential to enhance an individual's mood and productivity in the work environment by inducing feelings of comfort, good will, activeness, passiveness, or contentedness. Since a limited amount of research has explored the relationship of the interior work environment to the worker's performance and mood, additional research is needed before assumptions can be made concerning the effect of color on an individual in such a work environment.

Statement of the Research Problem

The purpose of this study was to investigate wall color in the work environment and the effect it may have on mood shifts and work performance. Of specific interest were the differences in the effect of using a warm hue versus a cool hue at similar value and intensity levels in identical work environment surroundings, as compared to a neutral color.

Objectives

The objectives of this study were to investigate the effects of 3 different colors used on painted vertical wall surfaces upon (a) the productivity of the office worker as measured by a standardized typing test which provided an errors-to-words-typed typing score and (b) the worker's anxiety, depression, and arousal mood levels as measured by the 8 State Questionnaire.

Hypotheses

For the purposes of hypothesis identification in this study white is referred to as a hue, even though white, technically, is a lack of hue being present. Thus, three hues were used in the study, identified as white or neutral, red or warm, and blue-green or cool.

1. Subjects working in a warm hue environment will have a higher typing score difference on post-test to pre-test than those subjects working in a cool hue environment.

2. Subjects working in a warm hue environment will have a higher typing score difference on post-test to pre-test than those subjects working in a neutral hue environment.

3. Subjects working in a neutral hue environment will have a higher typing score difference on post-test to pre-test than those subjects working in a cool hue environment.

4. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for arousal levels on the 8 State Questionnaire test than those in the cool hue environment.

5. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for arousal levels on the 8 State Questionnaire test than those in the neutral hue environment.

6. Subjects working in the neutral hue environment will have larger differences in post-test to pre-test scores for arousal levels on the 8 State Questionnaire test than those in the cool hue environment.

7. Subjects working in the cool hue environment will have larger differences in post-test to pre-test scores for depression levels on the 8 State Questionnaire test than those in the warm hue environment.

8. Subjects working in the cool hue environment will have larger differences in post-test to pre-test scores for depression levels

on the 8 State Questionnaire test than those in the neutral hue environment.

9. Subjects working in the neutral hue environment will have larger differences in post-test to pre-test scores for depression levels on the 8 State Questionnaire test than those in the warm hue environment.

10. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for anxiety levels on the 8 State Questionnaire test than those in the cool hue environment.

11. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for anxiety levels on the 8 State Questionnaire test than those in the neutral hue environment.

12. Subjects working in the neutral hue environment will have larger differences in post-test to pre-test scores for anxiety levels on the 8 State Questionnaire test than those in the cool hue environment.

Assumptions

1. Subjects will respond to the questionnaire honestly.

2. Subjects will follow the given instructions for completing the tasks requested in the test procedure.

3. Typing, filing and using the telephone are representative of the tasks encountered in an actual work environment.

Limitations

The researcher feels that the following may have a bearing on the results of this study.

1. A simulated work environment situation must be used rather than a true work environment.

2. The time of exposure in the colored room may be too short to give a significant degree of mood shift.

3. A limited age range will be used, and the mean age of the subjects (which will be relatively young in terms of a work force) may influence the study results. Younger subjects may be less sensitive to color in their work environment as they may not be accustomed to spending extended amounts of time in any one work environment situation.

4. This study will use only female subjects, who in reality may react differently than male subjects to color stimulation in the work environment.

5. Personal, outside characteristics of the participants may be more influential on the results of the test procedure than the actual room color.

6. The small size of the office environment space (close

proximity of the walls) may influence the color impact on the subjects.

Definition of Terms

1. Anxiety: Mood level in which one is worried, easily rattled, tense, emotionally upset, easily angered, high strung, easily annoyed.

2. Arousal: Mood level in which one is alert, keyed up, excited, stimulated, keen and exhibits sharp senses.

3. Color: The appearance of objects or light sources described in terms of the individual's perception of them, involving hue, intensity, and value of the objects.

4. Depression: Mood level in which one is unhappy, disagreeable, pessimistic, in poor spirits, disappointed.

5. Hue: A specific color (i.e. red, yellow, green.) In this study the term hue will refer to the three wall colors used in the study, even though white is technically not a hue. The term hue in this report will include white as well as red and blue-green.

6. Human response testing to color: The evaluation of human response, whether by physical reactions or emotional reactions, when exposed to a color stimulus such as a brightly colored room or color oriented tasks such as associating colors with objects.

7. Intensity: The level of saturation in any given hue which

refers to the relative purity or grayness of a hue, and affects the perception of that hue by the human eye (Bevlin, 1970). Munsell uses the term chroma rather than intensity in his description of color (Munsell, 1936).

8. Value: The level or measure of lightness or darkness of a given hue which affects the perception of that hue by the human eye. Each hue has a value range. The middle value of a given hue is equivalent to a medium gray. Values which run lighter than this middle value are considered tints, and values which run darker than this middle value are considered shades (Bevlin, 1970).

CHAPTER II

REVIEW OF LITERATURE

Introduction

The following will examine both historical and current literature concerning the use of color as it effects a human's physical and emotional responses. Topics reviewed will include relevant historical perspectives, color and light, colorimetry, color preference, examining human response to colors in general, and testing human response to color in the interior environment.

Throughout recorded history, color has played an important role. Just when human's passion for color began is not known, but evidence of color usage can be traced from cave wall drawings through the rich archeological ruins of ancient Eygpt, Greece, Rome, and China (Verity, 1980). World travelers today can experience the superb sense of color used by the ancient civilizations in art, architecture, sculpture, textiles, ceramics, and other objects. Color and decoration played distinctive roles in the ancient man's daily life. Colors ranged from the demure earth tones of the Eygptians to the brilliant polychrome used in Greek decoration. Color has been studied by the artist, the philosopher, the scientist, and the businessman.

Historical Perspectives on the Understanding of Color

Since Sir Isaac Newton established the fact that light was composed of color, researchers have been investigating the many

effects light and color have on all living species (Hunt, 1987; Paritsis and Stewart, 1983). To give a better perspective of the study of color science (including color theory and color vision) and the need to continue color research, a short historical review is necessary. Due to the early date and availability of the original research, it was not possible to cite certain primary sources. Reviews of important past perspectives presented from secondary sources include Birren (1969), Bouma (1971), Paritsis and Stewart (1983), and Hunt (1987).

From the days of Newton to today's current scientific and behavioral research, a number of theories and schools of thought have developed. These schools of thought are based both upon facts and upon intuition, and in many cases are contradictory.

In 1672, Newton first published the findings of his research conducted in 1666, in which he used light prisms to study the origin of color vision. He demonstrated that when white light was dispersed through a prism, a range of spectral colors was produced. When he dispersed only a part of the spectrum, no new hues were produced. When he recombined the spectrum he reproduced white light. Newton named the seven distinct spectrum colors violet, indigo, blue, green, yellow, orange and red (cited in Paritsis and Stewart, 1983; Hunt, 1987).

Following Newton, a number of well known scientists and philosophers, including Young, Goldstein, Granit, as well as Helmholtz and Goethe and others, conducted color research. Each researcher developed his own theories about the interactions of color and light and their effect on the human subject. These theories built the foundation for research that is being conducted today concerning color and human response.

Thomas Young conducted light studies around 1800, and was the first to develop the idea that there were three significant light sensitive receptors, known as color vision cones, in the human eye. This theory was known as the trichromatic theory of color vision. He also established the idea that there were situations of defective color vision in some individuals (i.e. red-blind and green-blind.) Young, a professor of natural philosophy and a believer in Newton's color vision theory, felt that the sensation of different colors depended on the different frequencies of vibrations, excited by light in the retina (cited in Paritsis and Stewart, 1983).

Goldstein theorized on the basis of his research done in 1939 (cited in Paritsis and Stewart, 1983) that red caused an increase in awareness and attraction to external stimuli, inducing a state of excitedness and emotional stimulation as well as physical motor stimulation. On the other hand, green was felt to evoke the subjects to withdraw from the external world and to decrease their awareness of external stimuli.

Granit was the first to assert that, based on neuro-physiological experiments, there was a distinct interaction of color vision with the nervous system (cited in Paritsis and Stewart, 1983). This may play a part in the physiological interaction between color and human response which many researchers are studying currently.

Color and Light

The study of color in any manner, including the study of human response to color, cannot be achieved independently from

the study of light or of colorimetry. There is no light without color and no color without light. White light is the presence of all colors blended together. An individual's perception of color is now known to be a neurophysiological process which requires both a physical receptor and a nervous system reactor (Bevlin, 1970). Although there are many aspects of this process which are not yet known nor understood, we do know that color is actually light broken down into electromagnetic vibrations. These vibrations create wave lengths and the visible portion of the variations in these wave lengths causes the viewer to see, and possibly to feel, different colors (Bevlin, 1970). Light is measured in nanometers (nm), the equivalent of one-millionth of a millimeter. Visible light is comprised of colors as demonstrated by Newton's research. The light waves which produce visible light fall in the range of 380 to 780 nm. Color in the form of these light wave lengths is received by cones in the retina of the eye which send information through the nervous system and to the brain. There are only three spectrally different type of cones in the retina. The perception of the color is not only based on the hue received, but is affected by the brightness and intensity of the hue (Hunt, 1987).

Colorimetry

The identification of the color hue, intensity and value of an object, as well as the description of the light interaction with an object or within a space affecting that hue, are necessary when studying human responses to color or to a colored environment. Colorimetry is the measurement and analysis of color by comparison with a standard or in terms of physical and spectral characteristics

(Great Encyclopedia Dictionary, 1975, p. 268). There are a number of colorimetry systems used that describe and measure color characteristics. The Munsell system of colorimetry (1936) is probably the most well known color system used today. Albert Munsell developed this system based on five primary hues consisting of red, yellow, green, blue, and purple, and five intermediate hues including yellow-red, green-yellow, blue-green, purple-blue, and red-purple. The hues are also assigned degrees of value (scaled from black at 0, to white at 10) and levels of intensity (with numbers from 1 to as high as 12 to 14). A color is then designated by hue, the value number, and the intensity number in the Munsell notation system. For example, school bus yellow would be described as 10YR7/10, which indicates the color of school buses is from the 10 yellow-red scale at the 7 level of value and at a 10 level of intensity.

Color Preference

The most well known diagnostic studies used to evaluate human response and color preferences have been conducted by Birren, Jaensch, Rorschach, Pfister, and Lüscher. Rorschach, Birren, and Lüscher all indicated that "normal" persons tended to prefer primary colors, while "disturbed" persons tended to choose white, gray, brown, and black. This would indicate the potential benefits of using color effectively in institutional situations (as cited in Paritsis and Stewart, 1983).

Faber Birren was one of the first researchers to do extensive work in evaluating color preferences and human response. Birren wrote his first book under the pen name of Martin Lang in 1940, after noting that people's reactions to a series of abstract colors displayed

on his studio wall were quite different and expressive. After pursuing the study of color response more extensively he concluded that, in general, it is normal for people to like any and all colors and that the rejection or denial of emotional response to colors indicates a disturbed, frustrated, or unhappy individual. However, over exuberance about color might also indicate mental confusion, a "flighty soul", and a lack of direction and self- poise. There appeared to be a major division between extroverts who seemed to prefer warm colors, and introverts who preferred cool colors (Birren, 1978, p. 78).

It has been suggested in some studies that personality traits can be identified through color preference selection. The full rainbow: Symbol of individuation, written by Rhinehart and Engelhorn (1984), described the use of color preference for personality trait identification and how opposite personality functions can be introduced through the use of color. Rhinehart and Engelhorn theorized that this process of using color to create opposite personality functions can be used to heal and provide psychological relief to individuals.

Kazimierz Ruda hypothesized that introvert and extrovert personality types would have varying preferences of color and shapes. To verify his assumption he tested 425 subjects of mixed social, economic, and educational backgrounds. Results showed that introverts and neurotics preferred dark, dim colors and irregular shapes, while extroverts and non-neurotics preferred bright, intense colors and symmetrical shapes (Ruda, 1983).

A study by Dornfeld correlated color preferences with anxiety levels in males and females. Subjects with a high level of anxiety chose dark colors more often than they chose light colors, and their

determination to reject bright colors was significantly greater than the subjects who had an average anxiety level (Dornfeld, 1982).

In a study by Nelson, Pelech, and Foster (1984) concerning color preference and stimulation seeking, a direct relationship between color preference and stimulation seeking was shown by the adolescent subjects evaluated. Both the males and the females who scored high on the Sensation Seeking Scale preferred the color red over blue. Those who scored low on the Sensation Seeking Scale preferred the color blue over red.

Max Lüscher's first test for measuring human response to colors was issued in 1947 and included a large number of colors mounted on seven panels. A shorter version of the test was developed in 1951 and today is commonly used in color preference evaluation. The short version includes eight colors (orange-red, bright yellow, blue-green, dark blue, violet, brown, neutral gray, and black) which people are asked to arrange in order of preference from left to right and top to bottom. Conclusions are then made about individual personalities based on preferences, dislikes, and combinations of preferences and dislikes (as cited in Paritsis and Stewart, 1983).

Max Pfister created the Color Pyramid Test designed to reveal deviant personality characteristics. This test has not been as widely used internationally as the Rorschach or Lüscher tests have been. Pfister's test used small squares of colors as did Lüscher's. Pfister concluded that persons who "scattered" the colors tended to be form dominated, while liberal users of red were extroverted personalities, and strong use of green by subjects seemed to indicate symptoms of psychological disturbances (as cited in Paritsis and Stewart, 1983).

In the area of color preference, the validity of research is often questioned due to the nature of construction of the test or its

interpretation method. In one review Smets' expressed such a concern based on a study he had completed. In this study college students were presented with a set of Munsell color chips of various hues, brightness, and saturation, and then asked to make differentiations based on their perception of pleasantness and unpleasantness. Saturation was determined to be responsible for 88% of the variation in judgments of pleasantness. Brightness was of less importance in deciding pleasantness of the hue, and the hue itself was almost irrelevant (0.66%) in the decision making process (Smets, 1982).

Human Response to Color

Hermann Rorschach, a Swiss art teacher, studied medicine and had a strong interest in mental illness. In the early part of the twentieth century, Rorschach created a series of psycho-diagnostic test plates using ink blots that are commonly known and used today. Part of the plates were done in black and white, and part were done in color. After studying clients' facial expressions and reactions to the plates, Rorschach concluded that people who seemed well adjusted to life liked color and those who rejected color or were distressed by it had tendencies toward schizophrenia (as cited in Paritsis and Stewart, 1983).

E. R. Jaensch worked in eidetic imagery, the study of the human recall of visual images. He concluded that blonde complexion types seemed to show different attitudes toward colors than brunets. His explanations of this phenomenon dealt with geography, sunlight, and pigmentation interactions. Jaensch found that fair- skinned Swedish people who were exposed to less sunlight over the course of the year exhibited different reactions to color than

dark skinned people of Africa who were exposed to greater amounts of sunlight per year (as cited in Paritsis and Stewart, 1983).

Robert Gerard (1957) used a highly sophisticated monitoring system to confirm the general feeling that red light is an arousing stimulus and blue a calming or sedative stimulus. Increased blood pressure, breathing rate and nervous system activity were found when subjects were exposed to red light. When exposed to blue light, the subjects had opposite reactions.

Prior associations and psychological perceptions of color have been theorized and tested as influencing an individual's physical and emotional response to color. A group of male college students were asked to squeeze a tennis ball in the palm of their hand while staring at either a red or a green wall. The test results of O'Connell, Harper and McAndrew (1985) showed that significantly greater strength scores were recorded when subjects were exposed to the red wall (in theory, a color of vigor and energy) than for subjects exposed to the green wall (a more sedate color).

In investigating whether there was a systematic relationship between human emotional response and color, Bernard Levy (1984) conducted two experiments. In the first experiment subjects reacted to three colors, an intense yellow, a pastel blue-violet, and a cool green with a blue cast. In the second experiment subjects reacted to a second set of three colors, a light blue-green, a dark mustard yellow, and a scarlet-vermillion. The results of the experiments strongly indicated that subjects responded in significantly different patterns of emotions, depending on the color placed before them. Such responses included the blue-violet color being associated with sadness and fatigue, while the cool green hue aroused anger and a feeling of confusion. The overall results consistently showed warm colors associated with feelings of activeness while cool colors tended

to be associated with feelings of sedation (Levy, 1984).

In a study conducted by the USAF School of Aerospace Medicine, it was shown that the visual properties of medications (i.e. color of the medication) evoked specific emotional responses in the subjects. Subjects ranked red and black capsules as most likely to contain the strongest medications, and white capsules as most likely to contain the weakest medications (Sallis and Buckalew, 1984).

Active children who found it hard to keep their attention on class activities and who were thought to be under-stimulated in their task requirements, were studied for their response to color by Zentall and Kruczek (1988). The subjects were found to respond better to minimally stimulating tasks when color emphasis was added to relevant details than when color was assigned randomly to selected letters.

Color response research has become an ever more important field in the past three decades as studies have shown the power that color can have over human emotion. Zhang and Lin's research (1984) showed that young children seem to have a natural love of color for the pure fun and enjoyment of it, preferring strong, pure, primary colors. As the children grew into adults they became less impulsive and more responsive to the subtleness of colors. Through education and acquired influences related to color, the human response became more sophisticated in its emotional reactions to color.

Adams (1987) found that adults and three month old babies showed a significant preference for different chromatic stimuli. The three month olds preferred the long wave length colors (red and yellow) and adults preferred the shorter wave length colors (blue and green.)

Other Factors Influencing Human Response to Color

Many human responses to color are learned or developed through association and may be culturally influenced. In addition, factors such as the type of lighting in a given space (i.e. natural daylight, artificial daylight, fluorescent, or incandescent) and the reflectancy of the surface (i.e. highly reflective versus diffusing surface finish) in a given space will also affect how color is perceived. Since these factors were being controlled in this particular study, no additional literature will be dedicated to these issues.

Human Response to Color in the Interior Environment

Jacob Nakshian (1964) conducted a research project verifying previous research by Goldstein (cited in Paritis and Stewart, 1983) on the emotional response to color. Nakshian studied three of the hypotheses derived from Goldstein's theory on the effects of red and green on human subjects in the interior environment. His results gave "very limited support" of Goldstein's theory that colored surroundings have an effect on psychomotor and intellectual functions. These effects were evidenced in two tasks concerning hand tremors and motor inhibition. Speed of movement on the motor inhibition task was significantly faster with the red wall surroundings than with the green wall surroundings.

Acking and Küller (1972) conducted a study to examine the perception of an interior based on its color. A total of 89 slides were made from sketches using various color profiles. Five different factors (personal evaluation, social evaluation, spatial enclosedness, complexity, and unity) were rated. Each slide was rated by at least 50 subjects. Conclusions included a lack of results in the factor of

pleasantness evaluation, a positive correlation between blackness and social evaluation, a positive correlation between lightness and perceived openness, a positive correlation between chromatic strength and perceived complexity, and vague results for the factor of unity. The results seemed to indicate systematic relationships between certain color dimensions and general perceptual dimensions.

The psychological effects of 4 primary colors on anxiety state was the focus of research by Jacobs and Suess (1975). They studied the interaction of color in the environment and human behavior. Jacobs and Suess used 35mm colored slides to produce colored screens which subjects observed while completing a State-Trait Anxiety Inventory. The findings of this study supported the general beliefs that red was more anxiety arousing than green, and that red created more anxiety arousal than blue.

Greene, Bell, and Boyers (1983) attempted to induce boredom in their subjects based on ten different color hues and sensation levels for the environment. The researchers believed that red, orange, and yellow hues would be more effective in resisting boredom than would green or blue hues. Yellow, gray, white, orange, and brown rooms were used in the test procedure. Each of the 140 under graduate subjects was tested individually, and completed the Emotional Response Scale both before and after the activity period. For this test the subjects were in a small laboratory room seated at a triangular carrel with walls extending 1.2 m above the table height. Two walls of the carrel exhibited panels painted alike in one of ten colors. During the activity period the subjects viewed a 10 minute audio-visual tape in which the words "door" and "chair" were repeated at specific intervals. The results suggested that only the yellow hue prompted a favorable evaluation of the

subject's environment, but the yellow hue did not appear to influence the person's feelings of boredom more or less than any of the colors. The boredom-induction procedures appeared to have had no reliable effects on any dependent measures.

In one study by Walter, Apter and Svebak (1982) of office workers' color response in relationship to arousal (based on a mood adjective checklist), the results indicated a tendency for high arousal feelings to be induced by an environment of long wave length colors (the warm end of the visible color spectrum of light.) In contrast, the short wave length colors (the cool colors in the visible color spectrum of light) tended to create feelings of low arousal. The results of the Walter, Apter and Svebak

study provide support for the hypotheses proposed in this current research which state that a warm hue office environment will be more arousing than a cool environment.

The most well known recent study on the effect of color in the environment was the work of Alexander Schauss (1985) using the Baker-Miller pink color in the treatment of individuals expressing aggressive behavior. The results of this study have been widely used in hospitals as well as criminal institutions around the United States. Schauss hypothesized that the Baker- Miller pink had a measurable effect on reducing physiological variables associated with aggression in subjects of normal intelligence. His research successfully demonstrated this hypothesis, and suggested that the use of the Baker-Miller pink to color an environment reduced the tendency toward aggressive behavior, and in fact, induced passive behavior. The effect has also been seen in individuals with either normal vision or with those with visual impairment, suggesting a physiological mechanism which is yet unknown.

The Alberta (Canada) School Planning Services branch

conducted a study to verify the effect of various lighting types and color surfaces in the environment in their relationship to health and ability to learn (Graves, 1985). In this study consideration was given to light and color as they affected mood, visual acuity, hyperactivity (noise level), intellectual development (IQ test scores), scholastic achievement, and illness rates. The Alberta study used four schools with an average enrollment of 700 students. Two color schemes (light and dark) plus the shielding and light source form of the lumanaires were used as variables. Noise levels were found to be lowest in the light colored schools, while blood pressure measured higher in the afternoon in those same schools. Blood pressure appeared to be influenced by the differences in color with cool colors cultivating relaxation and bright, warm colors encouraging alertness. Moods were most positive in the light colored school, while absences because of illness were higher in the schools where ultra-violet light was used. Although there were no significant differences in performance or behavior due to the color and light differences, physiological effects were found (Graves, 1985).

Rosenstein (1985) demonstrated that color in the environment did not affect everyone in the same manner and was not solely associated with the personalities of the subjects. In a test which correlated the effect of certain colors with sex and Scholastic Aptitude Test scores, Rosenstein found that while the colors did not affect the performance on the exam, they did affect the perceived mood of the subjects. Subjects in a red room were calmer than those in neutral or yellow rooms. Subjects in the red room rated themselves higher in terms of being in a good mood while subjects in the neutral colored room rated themselves the lowest on the mood scale (Rosenstein, 1985).

Recently, the question concerning the effect of color in the

work environment was addressed in a 1988 study by Kwallek, Lewis and Robbins. Using two color schemes (red/warm and blue/cool), four subject groups were evaluated using a mood scale rating and a typing task for performance rate (error rate). The mean anxiety and stress scores were higher for subjects working in the red room, while mean depression scores were higher for those in the blue room. A higher mean arousal score was achieved by those subjects who switched office spaces (from red to blue, or from blue to red) at the halfway point in the experiment. Additionally, the number of typing errors was higher for those who switched office colors than for those who remained in the same office color for the entire experiment (Kwallek, Lewis, and Robbins, 1988).

Summary

Historically, individuals' desire for color in their surroundings has been displayed through cave drawings, architecture, clothing, interior design, and art works throughout the world. Many researchers feel this is due to both an emotional and a physiological response to color in the environment.

In 1672 Newton demonstrated that light was composed of color and that white light is composed of all color wave lengths mixed together. From that time forward researchers such as Goethe, Young, Goldstein, Granit, Birren, and Lüscher have studied the manner in which color effects the individual.

Today we know that an individual's perception of color is a neurophysical process which is affected by the brightness and intensity of a hue. But there is much about the specific operations of that process which is still unknown. Color, as seen by the receptor cones in the human eye, is defined as the visible composition of

light, as well as the individual's perception of that light.

The use of colorimetry systems such as the Munsell system of color notation is a necessity in color response research to identify colors. The Munsell system standardizes colors by defining their characteristics in terms of hue, value and chroma, allowing for verification and duplication of hues.

Over the past three centuries color has been shown by researchers to have an emotional impact on the human response system. Hue preference, emotional responses and physiological responses to color have been studied actively for the past four decades by such noted researchers as Birren, Lüscher, Pfister and Rorschach. Research conclusions have been linked to personality types of individuals, physical make up (i.e. skin color), psychological factors, and physiological factors.

Many recent studies such as those conducted by Nakshian (1964), Schauss (1985), the Alberta School Planning Services branch (Graves, 1985), Rosenstein (1985), and Kwallek, Lewis and Robbins (1988) had focused on the effect of color in the interior environment on an individual's mood and physical performance. Results showed a relationship between emotional feelings reported and the presence of a particular hue in an individual's surroundings.

These studies have demonstrated the potential for using color to make people more comfortable, both physically and emotionally. Further research will reveal how color can be most positively used by individuals to control both physical and emotional stress. Additionally, color may be used to increase motivation and productivity in the work environment.

CHAPTER III

METHODOLOGY

This study investigated the possible effect color has upon individuals in an interior work environment. The specific area of investigation compared the differences in work performance and mood levels of subjects working in an environment of warm hue color on vertical wall surfaces versus a cool hue at the same value and intensity, and in comparison to a neutral color.

Characteristics of the Research Method

This was an applied behavioral research study which used pre test and post-test applications to determine measurable differences in work performance and mood level (Table 1).

Independent variable: Hue of the work environment walls (red at 5R5/6, blue-green at 5BG5/6, white at N9/78%R)

Dependent variables: Work performance (typing score); mood levels for anxiety, depression, arousal (scores on 8SQ)

Constants: Lighting, office arrangement, intensity and value of red and blue-green hues, subjects' sex and cultural background

Table 1
Research Design for Color in the Work Environment Study

Independent Variable*	n	Dependent Variables: Work Perform.	Mood, Anxiety	Mood, Depress.	Mood Arousal
Red	15	---	---	---	---
Blue-green	15	---	---	---	---
Neutral	15	---	---	---	---

*Wall hue

Experimental Environment

A single office space was used in this research procedure for all of the timed work activities and the post-tests. Only the mood pre-test was administered in a different location. The wall hue of the office space was varied for the three groups of subjects. The office space was painted a red hue of moderate value and intensity (Munsell 5R5/6) for the first group of subjects, then repainted a neutral hue (Munsell N9/78.7%R) for the second group of subjects, and repainted again in a blue-green hue of moderate value and intensity (Munsell 5BG5/6) for the third group of subjects (see Appendix A, Color Cards of Paint Hues). The office size was 15 feet by 10.5 feet with an 11 foot ceiling. The four side walls were painted the specified hues for conducting the study, with the exception of the top 1 foot which was painted to match the ceiling color. The ceiling and top 1 foot of the walls remained the same neutral color (Munsell N9/78.7%R, a slightly grayed white) for all of the testing groups and was the same as the neutral selected for the walls. The floor was a

brown marbled-effect, commercial brand, solid vinyl flooring tile.

The office space had one window on the south wall which had an off-white Venetian blind which was closed at all times to control possible variation of light effects upon the subject's mood. A layer of brown paper was placed between the window and the blind to ensure an even filtering out of bright external light. Incandescent lighting (2 semi-direct fixtures with a 300 watt pear shaped luminaire in each) was used to illuminate the office space.

No attempt was made to control exterior noise infiltration as this was considered part of a normal office situation. The subjects were provided with an electric typewriter, typical office furniture, and a telephone to complete the required activities. An attempt was made to control the temperature of the office at between $72^0F \pm 4^0F$, but due to difficulties with the heating system and poor ventilation, and changeable spring time weather the temperature fluctuated more, averaging $77^0F \pm 9^0F$ over the course of the three week investigation period. The beginning and ending temperatures were measured with a standard room thermometer and recorded for the period that each individual subject was in the colored office space. A large fan was used in the room when the temperature exceeded 74^0F to indirectly circulate the air. Each subject was asked when they finished if the room temperature was a concern for them.

Selection of Subjects

Volunteers for this study were recruited from the OSU College of Home Economics Apparel, Interior and Merchandising

courses 250 and 475, and were asked to complete and sign a preliminary questionnaire (Appendix B). In order to limit possible variation due to males and females reacting differently to colors in the environment, all subjects selected to participate in this research experiment were female. In an attempt to control variation due to the way different cultures use color in their environments, subjects selected had been American citizens for at least 10 years and were from a mixture of socio-economic backgrounds. Each subject was compensated for participating in this research study by earning extra points toward their course grade. Fifteen subjects were selected for each of the 3 groups to be tested since this was determined to provide a large enough sample for analysis.

Measurement Tools

Two experimental dependent variables, mood and work performance, were examined. Mood was measured by use of the Eight State Questionnaire (8SQ), Parts A and B (Curran and Cattell, 1985). This mood evaluation tool was selected, based upon its use in a previous study (Kwallek, et al., 1988) and upon the fact that it was one of the few previously tested tools used in mood-environment research. The mood levels measured by the 8SQ were anxiety, stress, depression, regression, fatigue, guilt, extroversion, and arousal; however, for the purposes of this study only the three areas of anxiety, depression, and arousal were analyzed (the Eight State Questionnaire, Parts A and B, 1974©, is available for purchase from the Institute for Personality and Ability Testing, Inc., Champaign, Illinois). These three areas were selected because they were thought most relevant to attitude in a work environment and had been used by Kwallek, et al. Data on all eight areas were collected for possible

later analysis, and may serve as the basis for future research. The 8SQ has a 96% reliability rating when both forms A and B are used for evaluation. The difference between the post-test and the pre-test scores was used to analyze the effect of the environment color on the subject's mood.

Forms A and B of the 8SQ each contained 96 questions with 12 questions for each of the 8 mood levels. For each question there were four possible choices, A through D, from which participants could select. Participants recorded their answers on a standard answer sheet provided with the tests. Answers were scored by hand using an overlay key for the 8 mood categories. Each possible answer was given a numerical rating of 1 through 4 points, with a total of 48 points possible for each mood level. A high score indicated a higher intensity or level of this mood.

$$\text{Mood Level Score, Individual} = \text{8SQ Post-test, individual} - \text{8SQ Pre-test, individual}$$

$$\text{Mood Level Score, Group Mean} = \Sigma \text{ 8SQ Individual Mood Level Scores} \,/\, \text{number of individuals}$$

Work performance was measured by calculating a Typing Score Difference, using standardized three minute timed typing tests published in the Gregg typing 191 series (Rowe, Lloyd, and Winger, 1962), located in Appendix C. A preliminary two minute typing test, which was not scored, was used as a warm-up exercise at the beginning of the research time just after completion of the 8SQ pre-test. The warm-up exercise was followed by a three minute timed typing test which was used to determine the ratio of errors-to-words typed at the start of the research period in the office environment (Pre-test Typing Score). A similar three minute timed typing test was used near the end of the timed research activity period, just

prior to the 8SQ mood post-test. This determined the Post-test Typing Score and allowed calculation of any change in typing performance while in the test work environment. The score for each of the timed typing tests was calculated by determining the ratio of the total number of typing errors made in 3 minutes divided by the total number of words typed in the 3 minute test. The Typing Score Difference used for each subject was the difference between the Post-test Typing Score and the Pre-test Typing Score. This Typing Score Difference was used to determine if the color of the environment had an effect on the quality of work performance of the subject.

$$\text{Typing Score Difference, Individual} = \text{Post-test Typing Score} - \text{Pre-test Typing Score}$$

where:

Post-test Typing Score = Total typing errors on post-test / total words typed on post-test

Pre-test Typing Score = Total typing errors on pre-test / total words typed on pre-test

$$\text{Typing Score Difference, Group Mean} = \Sigma \text{ Typing Score, Individual} / \text{number of individuals}$$

Procedure

The subjects were divided into three randomly assigned groups of 15 subjects per gro, for a total of 45 participants. All research activities were completed in the office environment with the exception of the 8SQ pre-test, which was administered immediately prior to entering the research environment. The first group completed the research activity when the office space was

painted the red hue, the second group completed the research activity when the office space was painted white or neutral, and the third group completed the research activity when the office space was painted the blue-green hue. Each subject undertook the research activities individually. Directions were given verbally to each participant prior to entrance into the office environment. Then when in the room alone, a series of seven folders provided the information on procedure as a reminder for them. This series of seven folders were labeled in sequence 1 through 7, and had the instructions posted on the front, with the materials needed to complete that activity inside the folder (Appendix D).

Upon arrival for the research activity each subject first completed the 8SQ pre-test in a given private space different from the office environment used for the testing activities. Approximately half the subjects completed part A of the 8SQ as the pre-test and the other half completed part B as the pre-test. The subjects then entered the painted office environment where they completed the scheduled office activities and the 8SQ post-test, remaining there for slightly over one hour. Each subject began the scheduled office activities with a two minute warm-up typing exercise (not scored), followed by a standardized three minute typing test to determine her Pre-test Typing Score. Following this activity the subject typed a given term paper for the next 20 minutes. The subject then completed a simple filing task consisting of sorting twenty four library style reference cards and placing them in the correct slot in a lateral wall file. The subject then made a phone call to a specified number where she was greeted by an answering machine and was required to leave a certain message on the machine. Having completed these tasks, designed to take approximately 40 minutes, the subject undertook the second

standardized three minute typing test to determine her Post-test Typing Score. The research activities were completed by taking the 8SQ post-test (the opposite form of the one which had been taken for the pre-test). The 8SQ pre-test and the 8SQ post-test each required approximately twenty minutes to complete. The total amount of time for completion of all research activities was noted for each participant to verify that each subject spent a minimum of one hour in the testing environment.

Statistical Analysis

A series of two sample t-tests were run to determine if there were any significant differences in either work performance or mood level changes between the warm (red) hue group, the cool (blue-green) hue group, and the neutral (white) group. A 95% significance level (alpha = .05) was used. The t-test comparisons were calculated for cool hue group versus warm hue group, cool hue group versus neutral group, and warm hue group versus neutral group. Dependent variables analyzed were work performance (typing score) and the three mood levels (anxiety, depression, arousal). A total of 12 t-tests were completed (3 hue group combinations x 4 dependent variables). The STATGRAPHICS (1987) computer software program was utilized in the statistical analysis.

CHAPTER IV

DISCUSSION OF RESULTS

This behavioral study examined the relationship of work environment hue to two dependent variables, work performance and mood levels. Work performance was measured by a Typing Score Difference, while the 3 mood levels of anxiety, depression, and arousal were measured on the Eight State Questionnaire (8SQ) developed by Curran and Cattel (1985). Subjects worked in the colored work environment for a one hour period.

Work Performance Test Results

Mean scores for work performance for the 3 environmental hues are reported in Table 2. Words typed on the post-test for the red, blue-green and white environments averaged 151.80, 112.53, and 117.67 respectively; while on the pre-test the scores were 161.53, 102.87, and 115.20. Although mean scores for words typed were seemingly different for each group, when the Typing Score Difference ratios of errors-to-words-typed were calculated for each group, it became apparent that there were no or only slight differences between the groups. This method of measuring work performance by calculating Typing Score Differences was advantageous in that individual variations in typing speeds were eliminated as a factor, and both errors and typing speed were considered in arriving at the scores.

Table 2

Mean Typing Scores of Work Performance for 3 Environmental Hues

		Post-test			Pre-test			Typing
Group	n	Words typed	Errors	Typing Score[a]	Words typed	Errors	Typing Score[b]	Score Diff.[c]
Red	15	151.80	9.60	.06	161.53	10.47	.06	.00
B-G	15	112.53	6.47	.01	102.87	7.13	.00	.01
White	15	117.67	9.00	.08	115.20	7.73	.07	.01

[a] Post-test Typing Score = number of errors / number of words typed on the 3 minute post-test.

b Pre-test Typing Score = number of errors / number of words typed on the 3 minute pre-test.

c Typing Score Difference, = Σ Typing Score Difference, Individual / Group Mean number of individuals.

Results of the two sample t-test for Typing Score Difference, as determined by the ratio of the number of errors made to the number of words typed, are exhibited in Table 3. The t-test results confirmed that no significant differences in typing performance (at the 95% confidence level) existed between the red versus the blue-green, the red versus the white, and the white versus the blue-green groups. Therefore, hypotheses 1 and 2, which theorized that a red/warm work environment would evoke a higher errors-to words typed ratio by subjects than would the white/neutral or the blue-green/cool environments, were rejected. Additionally, hypothesis 3, which stated that the subjects in the white/neutral environment

Table 3
Typing Score Difference t-test Analysis

Hues	Mean	St. Dev.	T-Stat.*	Probability Value
Red vs. B-G	+.01	.03	+ .61	.54 NS
Red vs. White	+.00	.03	+ .90	.37 NS
White vs. B-G	+.00	.03	+1.36	.18 NS

* at 95% significance level

In comparison, a previous study of interior hue environment and work performance done by Kwallek, et al. (1988) examined the number of typing errors for subjects who worked in red and blue office environments. Analysis of typing errors was made, based on (a) subjects who worked in a red office environment for the entire testing period, (b) those who worked in a blue environment for the entire testing period, (c) subjects who changed from a red to a blue environment half way through the testing period, and (d) those who changed from a blue to a red envrironment half way through the testing period. No significant differences in the amount of typing errors were found between any of the 4 groups tested. The mean typing errors of subjects switching from the blue environment to the red one was higher than all of the other groups, but the amount of errors made when typing in the red environment was not significantly different when the same group typed in the blue environment. Thus, the difference seen in error rates was attributed to the changing of environments rather than the actual hue of the environment.

The Kwallek, et al. research was similar to this study in that the effects of warm and cool hues in the work environment were

examined and that typing skills (specifically typing errors) were used as an evaluation tool for measuring change in work performance. Their research results support the findings of this current study. Kwallek, et al. found no significant differences in typing errors made by subjects remaining in any of the different hue environments (i.e. differences were noted only when switching environments), just as no significant differences in Typing Scores Differences were found in this current study for the different hues.

Mood Level Test Results

The relationship of the work environment hue to the mood levels of anxiety, depression and arousal in subjects was examined. The mood scores were determined by differences in the 8SQ post-test compared to pre-test scores.

Anxiety Mood Level Results

Anxiety is defined by the 8SQ test as the state of being easily annoyed or upset, being high strung and having higher susceptibility to embarrassment and a lower self confidence level in completing previously untried skills (Curran and Cattel, 1985). The average difference in test scores (the post-test minus the pre-test) for the anxiety mood level of subjects in the red environment was .26, in the blue environment was .54, and for subjects in the neutral or white environment it was -.60 (Table 4). Differences in the three possible environmental hue comparisons showed only small values of -0.17 to +0.40, and were not statistically significant at the 95% confidence level (Table 5). Thus hypothesis 4, 5, and 6 were not accepted as holding true, as anxiety scores were not significantly

affected by the 3 hues.

This current project supported the findings of Kwallek, et al. (1988). In their study there were no statistically significant differences in anxiety scores between subjects in the different colored environments, although mean anxiety scores for the subjects who remained in the red office were slightly higher than for the subjects in the other hue environments. Since the subjects in the Kwalleck, et al. study were in the colored office environment for less than one hour, and that hour was interrupted, more extensive studies may find that there is a significantly higher level of anxiety in red office environments than in cooler hue office environments. In contrast, Jacobs and Suess (1975) found supporting evidence that a red environment created more anxiety than a blue environment based on a State-Trait Anxiety Inventory.

Table 4
Mean Mood Level of Anxiety for 3 Environmental Hues

Group	n	Post-test	Pre-test	Score Diff.[a]
Red	15	11.73	11.47	.26
B-G	15	12.47	11.93	.54
White	15	15.40	16.00	-.60

[a] Mood Level Score , = Σ 8SQ individual Mood Scores
group mean / number in group

Table 5
Anxiety Levels t-test Analysis

Hues	Mean	St. Dev.	T-Stat.*	Probability Value	
Red vs. B-G	+ 0.40	5.04	- .15	.89	NS
Red vs. White	- 0.17	5.40	+ .44	.66	NS
White vs. B-G	- 0.03	6.34	- .49	.63	NS

* at 95% confidence level

Depression Mood Level Results

Depression is described by the 8SQ as the state of being in poor spirits, exhibiting disagreeable behavior, and having a low ratio of fluency regarding oneself in relation to other topics. The average difference between pre-test and post-test scores of the depression mood level for subjects in the red environment was 0.60, for the blue-green environment 1.87, and for the neutral white environment 1.00 (Table 6). Differences in the three environmental hue comparisons showed values of 0.80 to 1.43 (Table 7). These results were not statistically significant at the 95% confidence level. Thus hypotheses 4, 5, and 6 were rejected.

These results support findings by Kwallek, et al. (1988) that there were no significant differences in depression levels between subjects working in the red environment and those working in the blue environment. Although the findings of the Kwallek study were not statistically significant, they did find that mean depression scores were slightly higher for the subjects in the blue environment than in the red environment. This was also true in the current research project although white was even more depressing than

blue.

Table 6
Mean Mood Level of Depression for 3 Environmental Hues

Group	n	Post-test	Pre-test	Score Diff.[a]
Red	15	12.67	12.07	0.60
B-G	15	13.27	11.40	1.87
White	15	14.60	13.60	1.00

[a] Score Diff., group mean = Σ 8SQ individual Mood Scores / number in group

Table 7
Depression Levels t-test Analysis

Hues	Mean	St. Dev.	T-Stat.*	Probability Value
Red vs. B-G	+ 1.23	6.45	- .54	.60 NS
Red vs. White	+ 0.80	6.20	- .18	.86 NS
White vs. B-G	+ 1.43	6.57	- .36	.72 NS

* at 95% confidence level

Arousal Mood Level Results

Arousal levels are described by the 8SQ as the quality of alertness, excitability, and stimulation. Mean arousal difference scores ranged from +0.06 in the red environment to -1.73 in the blue-green environment, and up to 1.60 in the neutral environment (Table 8). Mean arousal level differences between the groups in the 3 colored environments ranged from -0.83 to +0.57, with no significant differences evident at the 95% confidence level. Thus,

hypotheses 10, 11, and 12 all were rejected (Table 9).

In a study of office workers done by Walter, et al. (1982), findings showed a tendency for high arousal feelings to be induced by an environment of warm colors, while feelings of low arousal were induced by cool colors. However, this present study resulted in no evidence to support Walter's findings. The study by Kwallek, et al. (1988) also did not support the hypothesis that arousal is greater in the warm hue environment than in the cool hue environment.

Table 8
Mean Arousal Mood Level Scores for 3 Environmental Hues

Group	n	Post-test	Pre-test	Score Diff.[a]
Red	15	18.33	18.27	0.06
B-G	15	18.07	19.80	- 1.73
White	15	18.13	17.07	1.60

[a] Score Diff., group mean = Σ 8SQ individual Mood Scores / number in group

Table 9
Arousal Levels t-test Analysis

Hues	Mean	St. Dev.	T-Stat.*	Probability Value	
Red vs. B-G	- 0.83	4.96	+ .99	.33	NS
Red vs. White	+ 0.57	5.66	- .48	.63	NS
White vs. B-G	- 0.33	5.28	+ 1.45	.16	NS

* at 95% confidence level

Summary of Results

In the two sample t-test analyses at the 95% confidence level

no significant differences were found between subjects in the different hue environments. The combination of environmental hue comparisons (red versus blue-green, red versus white, white versus blue-green) showed no marked differences for any of the four dependent variables of work performance and mood levels for anxiety, depression and arousal. All twelve hypotheses were rejected at the 95% confidence level.

CHAPTER V

CONCLUSIONS

This behavioral research study was designed to investigate the effect of hue (cool versus warm) or lack of hue (neutral) on vertical surfaces in an office environment upon an office employee's work performance and mood shifts. Hypotheses 1 through 3 examined work performance, while hypotheses 4 through 12 examined mood changes.

Hypothesis 1. Subjects working in a warm hue environment will have a higher typing score difference on post-test to pre-test than those subjects working in a cool hue environment.

At the 95% confidence level no significant differences in typing scores were found for subjects in the warm hue environment as compared to the cool hue environment. Therefore, the hypothesis was not accepted. Subjects working in the red office space were not significantly different in typing performance than those who worked in the blue-green office space.

Hypothesis 2. Subjects working in a warm hue environment will have a higher typing score difference on post-test to pre-test than those subjects working in a neutral hue environment.

No significant differences at the 95% confidence level were found in typing performance differences between the subjects working in the warm hue environment and those working in the

neutral hue environment. The hypothesis was not accepted.

Hypothesis 3. Subjects working in a neutral hue environment will have a higher typing score difference on post-test to pre-test than those subjects working in a cool hue environment.

At the 95% confidence level no significant differences in typing scores were found between the subjects in the neutral hue environment and those in the cool environment. Thus, the hypothesis was rejected.

Hypothesis 4. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for arousal levels on the 8SQ test than those in the cool hue environment.

At the 95% confidence level no significant differences were found between the 8SQ arousal scores of the subjects in the warm hue environment and those in the cool hue environment; therefore, the hypothesis was rejected.

Hypothesis 5. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for arousal levels on the 8SQ test than those in the neutral hue environment.

The hypothesis was rejected since no significant differences were shown between the 8SQ arousal scores of the subjects in the warm hue environment and those subjects in the neutral environment, using a 95% confidence level.

Hypothesis 6. Subjects working in the neutral hue

environment will have larger differences in post-test to pre-test scores for arousal levels on the 8SQ test than those in the cool hue environment.

At the 95% confidence level no significant differences were found between the 8SQ arousal scores of the subjects working in the neutral office environment and those subjects who worked in the cool hue environment. Therefore, this hypothesis was not accepted.

Hypothesis 7. Subjects working in the cool hue environment will have larger differences in post-test to pre-test scores for depression levels on the 8SQ test than those in the warm hue environment. This hypothesis was rejected since at the 95% confidence level no significant differences were found between the 8SQ depression scores of the subjects working in the cool hue office environment and those subjects who worked in the warm hue environment.

Hypothesis 8. Subjects working in the cool hue environment will have larger differences in post-test to pre-test scores for depression levels on the 8SQ test than those in the neutral hue environment.

No significant differences were found between the 8SQ depression scores of the subjects working in the cool hue office environment and those of the subjects who worked in the neutral office environment. The hypothesis was not accepted.

Hypothesis 9. Subjects working in the neutral hue environment will have larger differences in post-test to pre-test scores for depression levels on the 8SQ test than those in the warm hue environment.

At the 95% confidence level no significant differences were found between the two groups of subjects working in the neutral environment and the warm hue environment in their 8SQ depression scores. Therefore, the hypothesis was rejected.

Hypothesis 10. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for anxiety levels on the 8SQ test than those in the cool hue environment.

At the 95% confidence level no significant differences were found between the 8SQ anxiety scores for the subjects working in the cool office environment and the anxiety scores of those working in the warm office environment. The hypothesis was rejected.

Hypothesis 11. Subjects working in the warm hue environment will have larger differences in post-test to pre-test scores for anxiety levels on the 8SQ test than those in the neutral hue environment.

Again, no significant differences at the 95% confidence level were found between the 8SQ anxiety level scores of the subjects working in the warm hue office environment and the subjects working in the neutral office environment. Hence, the hypothesis was not accepted.

Hypothesis 12. Subjects working in the neutral hue environment will have larger differences in post-test to pre-test scores for anxiety levels on the 8SQ test than those in the cool hue environment.

This hypothesis was rejected since at the 95% confidence level no significant differences were found between the 8SQ anxiety scores

of the two sets of subjects. Participants working in the cool hue office environment, those in the neutral environment, and those who worked in the warm hue environment showed no significant levels of anxiety differences in comparison to one another.

Summary

There were no significant differences found for any of the twelve hypotheses at the 95% confidence level. Therefore, there is evidence to support the statement that there are no significant effects for persons working in a warm hue environment versus those working in a cool hue or in a neutral hue environment for a one hour period.

Subjects working in a colored environment for a limited one hour time period did not generally exhibit any significant emotional changes in mood levels or in physiological signs (as manifested by changes in typing performance). This does not preclude the fact that the color of the environment may be influential for an extended work period of eight hours or several days. Because the subjects used in this study were college students leading very active lives, this researcher believes that a one hour period of exposure to a colored work environment may have had little influence. For college students it is routine to go from one style or color of work environment to a different work environment every hour or two. Therefore, they have become emotionally and physically adjusted to accommodate that change. As this is routine for these college women, very limited amounts of physical or emotional response to the testing process could be expected. A longer exposure to the colored work environment may cause the subjects to exhibit a more measurable reaction to that environment.

In addition, the actual responses may have been influenced by outside variables. For many of the subjects, the experimental process used in this study may have been a relaxing break from the learning and assimilation of information. Since the research activities did not require a great deal of physical or mental exertion, just simply following directions and completing the activities at one's own pace, it may have been a relaxing break for many subjects. For other subjects this activity may have been just one more thing to fit into their already busy day. However, these two reactions may have counterbalanced one another.

The age of the subjects also may have been a factor in the results of this study. Often as a person grows older it is more difficult to adjust to change, and a greater preference is usually shown for more subtle colors in our environment. Since the subjects used in this research were relatively young, ranging from 18 to 24, environmental change and more intense colors may not have been as much of a disrupting influence for them as it would be for older office workers who are accustomed to working in the same environment daily for an extended number of months or years.

Recommendations

Additional long term research using an actual work environment and office workers would be preferred to investigate the significant influences of different colors in the work environment. Using subjects more typical of office workers in age and activities would provide a better population for testing.

Future research is also needed to explore the use of various hues in the work environment based on the type of activities expected to take place in that environment. Warm hues might be

more appropriate for areas where very active work performance is needed and cool hues where more sedate work activities take place.

REFERENCES

Acking C., and Küller, R. (1972). The perception of an interior as a function of its colour. Ergonomics, 15 (6), 645-654.

Adams, R. (1987). An evaluation of color preference in early infancy. Infant Behavior and development, 10 (2), 143-150.

Bevlin, M. (1970). Design through discovery. New York: Holt.

Birren, F. (1969). Light, color, & environment. New York: Van Nostrand.

Birren, F. (1978). Color & human response. New York: Van Nostrand.

Bouma, P. J. (1971). Physical aspects of colour. New York: St.Martin's Press.

Curran, J. P. and Catell, R. B. (1985). Eight State Questionnaire. Champaigne, Illinois: Institute for Personality and Ability Testing.

Dornfeld, R. (1982). Colour preference and the level of anxiety. Pozniki-Filozofiozna-Psychologia, 30F (4), 61-72.

Gerard, R. (1957). Differential effects of colored lights on psychophysical functions. Unpublished doctoral dissertation on file with librarian. University of California, Los Angeles.

Graves, B. (1985). Facility planning; shedding light on learning. American School & University 57, 88-90.

Great encyclopedia dictionary. (1975). New York: Funk & Wagnoll's, p. 268.

Greene, T., Bell, P., and Boyer, W. (1983). Coloring the environment: hue, arousal, and boredom. Bulletin of the Psychonomic Society, 21 (4), 253-254.

Hunt, R.. (1987). Measuring colour. New York: J. Wiley & Sons, Inc.

Jacobs, K., and Suess, J. (1975). Effects of four psychological primary colors on anxiety state. Perceptual and Motor Skills, 41 (1), 207-210.

Kwallek, N., Lewis, C., and Robbins, A. (1988). Effects of office interior color on workers' mood and productivity. Perceptual and Motor Skills, 66 (1), 123-128.

Levy, B. (1984). Research into the psychological meaning of color. American Journal of Art Therapy, 23 (2), 58-62.

Lüscher, M. (1969). The Lüscher color test. (I. Scott, Trans. and ed.) New York: Random House.

Munsell, A.H., (1936). A color notation. Baltimore: Munsell Color Co.

Munsell color. (1976). Munsell book of color; glossy finish collection, 2.5r-10g. Baltimore: Macbeth, a division of Killmorgen Corp.

Nakshian, J. S. (1964). The effect of red and green surroundings on behavior. The Journal of General Psychology, 70 (1), 143-161.

Nelson, J., Pelech, M., and Foster, S. (1984). Color preference and stimulation seeking. Perceptual and Motor Skills, 59 (3), 790.

O'Connell, B., Harper, R., and McAndrew, F. (1985). Grip strength as a function of exposure to red or green visual stimulation. Perceptual and Motor Skills, 61 (3, pt 2), 1157-1158.

Paritsis, N., and Stewart, D. (1983). A cybernetic approach to colour perception. New York: Gordon & Breach.

Rhinehart, L., and Engelhorn, P. (1984). The full rainbow: Symbol of individuation. Arts in Psychotherapy, 11 (1), 37-42.

Rosenstein, L. (1985). Effect of color of the environment on task performance and mood of males and females with high or low scores on the scholastic aptitude test. Perceptual and Motor Skills, 60 (2), 550.

Rowe, J., Lloyd, A., Winger, F. (Eds.). (1962). Gregg typing 191 series: Book one general typing. New York: McGraw-Hill Book Co., Inc.

Ruda, K. (1983). Personality determinants of aesthetic preferences: H. Eyttnk's theory. Przeglad Psychologiczny, 26 (2), 311-325.
Sallis, R., and Buckalew, L. (1984). Relation of capsule color and perceived potency. Perceptual and Motor Skills, 58 (3), 897-898.

Schauss, A. G. (1985). The physiological effect of color on the suppression of human aggression: research on Baker-Miller pink. International Journal of Biosocial Research, 7 (2), 55-64.

Smets, G. (1982). A tool for measuring relative effects of hue, brightness and saturation on color pleasantness. Perceptual and Motor Skills, 55 (3, pt 2), 1159-1164.

STATGRAPHICS User's guide. (1987). USA: STSC, Inc.

Walters, J., Apter, M., and Svebak, S. (1982). Color preference, arousal, and the theory of psychological reversals. Motivation and Emotion, 6 (3), 193-215.

Verity, E. (1980). Color observed. New York: Van Nostrand.

Zentall, S., and Kruczek, T. (1988). The attention of color for active attention problem children. Exceptional Children, 54 (4), 357-362.

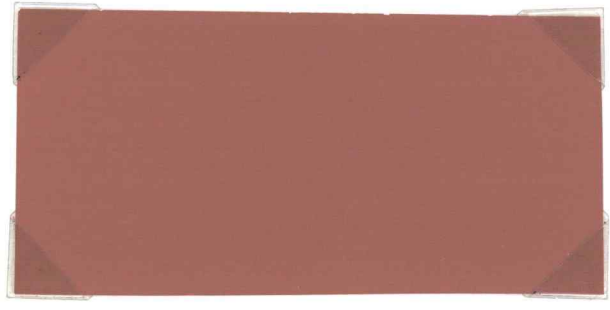
Zhang, Z., and Lin, Z. (1984). Color matching, color preference and color naming in young children aged 1.5-3 years. Information on Psychological Sciences, 1 (1), 7-13.

APPENDICES

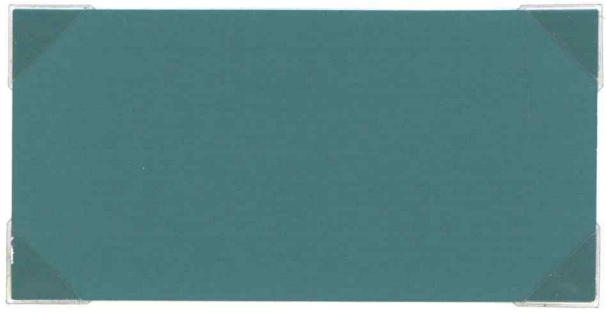
APPENDIX A

COLOR CARDS OF PAINT HUES

MUNSELL 5RED5/6



MUNSELL 5BLUE-GREEN5/6



MUNSELL NEUTRAL SCALE 9/78%R

APPENDIX B

VOLUNTEER QUESTIONNAIRE

OFFICE ENVIRONMENT VOLUNTEER QUESTIONNAIRE

NAME_____

BIRTHDATE_____ CAMPUS TELEPHONE_____

SCHOOL MAILING ADDRESS_____

_____

FEMALE_____ MALE_____

ARE YOU AN AMERICAN CITIZEN ?_____YES_____NO

IF YES, HOW MANY YEARS HAVE YOU BEEN A CITIZEN?____

IF NO, PLEASE LIST COUNTRY OF ORIGIN? _____

HOME STATE OF RESIDENCE WHEN NOT IN SCHOOL?_____

YEAR IN COLLEGE _____ FRESHMAN _____SOPHOMORE

_____JUNIOR _____SENIOR ____GRAD.

MAJOR AREA OF STUDY? _____

DEPT. _____

PLEASE INDICATE THE LEVEL AT WHICH YOU BELIEVE YOUR TYPING SKILLS ARE;

_____LOW: UNDER 40 WORDS PER MINUTE

_____MODERATE: 40 TO 60 WORDS PER MINUTE

_____HIGH: 60 OR MORE WORDS PER MINUTE

DO YOU FIND TYPING TO BE A FRUSTRATING TASK FOR YOU?

_____NOT AT ALL FRUSTRATING

_____A LITTLE FRUSTRATING

_____ MODERATELY FRUSTRATING

_____ VERY FRUSTRATING

THE RESEARCH ACTIVITY FOR WHICH YOU ARE VOLUNTEERING REQUIRES EACH INDIVIDUAL TO COMPLETE A PRE-TEST, APPROXIMATELY 30 MINUTES WORTH OF OFFICE MANAGEMENT AND TYPING TASKS, AND A POST-TEST ACTIVITY. THE TOTAL PERIOD TO COMPLETE ALL ACTIVITIES WILL BE APPROXIMATELY 90 MINUTES. EACH VOLUNTEER WILL RECEIVE EXTRA CREDIT POINTS FOR PARTICIPATION IN THIS RESEARCH ACTIVITY AS PRE- ARRANGED WITH THE COURSE INSTRUCTOR. IF SELECTED TO PARTICIPATE IN THIS STUDY YOU WILL BE NOTIFIED AS A LIMITED NUMBER OF VOLUNTEERS ARE NEEDED.

VOLUNTEER SIGNATURE:_____

APPENDIX C

THREE MINUTE TIMED TYPING TESTS

PRE-TEST

For more than a year now, it has been my pleasure each morning t study the window of a fine jewelry store that is located at the corner where I catc the bus. I get there a few minutes before eight and have to wait six or seven minu before the bus is due to stop for me. While I wait, I look at a special display of clocks, which is quite a sight to see, for there are clocks of all shapes and sizes. M of the clocks are not going, and the few that are going are out of step with each other, you might say. If I owned the store, I think I would try to make a better sh than that.

[Total words typed in pre-test is 240.]

POST-TEST

Many writers have tried to copy or equal the writing style of Mark Twain. No one yet has been successful. It seems to be next to impossible to catch the spirit with which he wrote, the love of adventure that sparkles in the tales he wrote, or just the right touch of twinkle in his sly humor.

In some fields of work, it is a good idea to select the top man in the field and study him, to determine what he did to become what he is. Such analysis tells you what you may have to do, or do without, to match his marked success by your own.

But this plan does not work when you turn to writing for a career. Oh, a study of the working habits and tricks of the trade of good authors is helpful in a technical way, that's true. But the roadway is rocky, and only when you have paved it with the embers of many manuscripts is it smooth.

[Total words typed in post-test is 170.]

APPENDIX D

ACTIVITY FOLDERS INSTRUCTIONS

FOLDER #1 INSTRUCTIONS

ENCLOSED IS A TWO MINUTE TIMED WARM-UP TYPING EXERCISE. REMOVE THE SANDWICHED CARBON AND TYPING PAPER SET FROM THE FOLDER (ALL THREE SHEETS TOGETHER), REMOVE THE PAPERCLIP AND INSERT THE PAPERS INTO THE TYPEWRITER USING THE PAPERGUIDE TO ALIGN THE PAPERS IN THE MACHINE. USING THE WARM-UP EXERCISE PROVIDED IN THE FOLDER, SET TIMER "A" FOR TWO MINUTES AND THEN TYPE THROUGH THE EXERCISE. IF YOU COMPLETE THE PARAGRAPH IN LESS THAN TWO MINUTES, START AT THE BEGINNING AGAIN.

UPON COMPLETION OF THE WARM-UP PERIOD (WHEN THE TIMER GOES OFF), REMOVE THE PAPER FROM THE TYPEWRITER, PLACE IT BACK INTO THE FOLDER, AND THEN GO TO FOLDER #2 FOR THE NEXT SET OF INSTRUCTIONS.

FOLDER #2 INSTRUCTIONS

IN THIS EXERCISE YOU WILL COMPLETE A THREE MINUTE TIMED TYPING EXERCISE. INSERT THE SANDWICHED TYPING PAPER AND CARBON INTO THE MACHINE AS BEFORE, PLACE THE TIMED TYPING TEST WHERE IT IS EASIEST FOR YOU TO READ TO TYPE FROM, SET TIMER "A" FOR 3 MINUTES AND PROCEED WITH THE TYPING.

SINCE THIS TYPEWRITER HAS NO CORRECTION KEY, YOU MAY BACKSPACE AND TYPE OVER THE EXISTING LETTER(S) TO CORRECT ERRORS BUT DO NOT TRY TO REMOVE ERRORS AS THIS IS TIME CONSUMING FOR YOU.

PLEASE STOP TYPING AS SOON AS THE TIMER GOES OFF! REMOVE THE PAPER FROM THE TYPEWRITER AND INSERT IT BACK INTO THE FOLDER FROM WHICH YOU TOOK IT. GO ON TO THE ASSIGNMENT IN FOLDER #3.

FOLDER #3 INSTRUCTIONS

PUT TWO PIECES OF THE TYPING PAPER PROVIDED INTO THE MACHINE (USING DOUBLE THICKNESS IS BETTER FOR THE MACHINE CARRIAGE). PUT THE ENCLOSED TERM PAPER WHERE YOU CAN COMFORTABLY TYPE FROM IT, SET TIMER "A" FOR 20 MINUTES AND SPEND THE FOLLOWING 20 MINUTES RE-TYPING THE TERM PAPER. YOU WILL NOT BE EXPECTED TO FINISH TYPING THE TERM PAPER, BUT SHOULD COMPLETE AS MUCH OF IT AS YOU POSSIBLY CAN IN THE TIME ALLOWED.

WHEN THE TIMER GOES OFF PLEASE STOP TYPING AND REMOVE THE PAPER FROM THE MACHINE. PUT ALL COMPLETED TYPING BACK INTO THE FOLDER ALONG WITH THE TERM PAPER, AND THEN PROCEED TO THE NEXT FOLDER TASK.

FOLDER #4 INSTRUCTIONS

IN THIS FOLDER YOU FIND A SET OF LIBRARY CARDS. PLACE THE CARDS IN ALPHABETICALLY ORDER AND THEN FILE THEM IN THE APPROPRIATE FILE FOLDERS HANGING ON THE WALL TO THE RIGHT OF THE TYPEWRITER MARKED FILING EXERCISE. THIS IS NOT A TIMED EXERCISE, SO DO NOT FEEL RUSHED TO COMPLETE THIS TASK.

WHEN YOU ARE FINISHED, GO ON TO FOLDER #5.

FOLDER #5 INSTRUCTIONS

FOR THIS TASK YOU NEED TO PLACE A TELEPHONE CALL. TELEPHONE THE NUMBER GIVEN BELOW. YOU WILL BE ANSWERED BY AN ANSWERING MACHINE. PLEASE LEAVE THE DATE, AND THE TIME AS WELL AS THE MESSAGE WHICH IS GIVEN TO YOU BELOW.

TELEPHONE NUMBER: 9-753-0502

MESSAGE: TODAY'S DATE IS _____ AND IT IS NOW APPROXIMATELY _____(TIME). I AM CALLING YOU AS PART OF A RESEARCH STUDY CONDUCTED BY REBECCA FOR HER MASTERS THESIS. THANK YOU.

IF TIMER "B" HAS GONE OFF, PROCEED TO FOLDER #6.

IF TIMER "B" HAS NOT GONE OFF, RETURN TO FOLDER #3 AND CONTINUE TO RE-TYPE THE TERM PAPER THAT YOU HAD PREVIOUSLY STARTED. YOU MAY WISH TO START WITH A FRESH SHEET OF PAPER RATHER THAN TRYING TO RE-INSERT THE PAPER YOU PREVIOUSLY ENDED ON FOR THAT TASK. WHEN TIMER "B" GOES OFF, STOP TYPING, REMOVE YOUR PAPER AND PLACE IT BACK INTO FOLDER #3. PROCEED TO FOLDER #6.

FOLDER #6 INSTRUCTIONS

FOR THIS TASK YOU NEED TO COMPLETE ANOTHER THREE MINUTE TIMED TYPING TEST. INSERT THE SANDWICHED TYPING PAPER AND CARBON INTO THE MACHINE AS BEFORE, PLACE THE TIMED TYPING TEST WHERE IT IS EASIEST FOR YOU TO READ TO TYPE FROM, SET THE TIMER FOR 3 MINUTES AND PROCEED WITH THE TYPING.

AGAIN, SINCE THIS TYPEWRITER HAS NO CORRECTION KEY, YOU MAY BACKSPACE AND TYPE OVER THE EXISTING LETTER(S) TO CORRECT ERRORS BUT DO NOT TRY TO REMOVE ERRORS AS THIS IS TIME CONSUMING FOR YOU.

PLEASE STOP TYPING AS SOON AS THE TIMER GOES OFF. REMOVE THE PAPER FROM THE TYPEWRITER AND INSERT IT BACK INTO THE FOLDER.

GO ON TO FOLDER #7.

FOLDER #7 INSTRUCTIONS

YOUR FINAL TASK IS TO COMPLETE THE POST-TEST GIVEN TO YOU IN THIS FINAL FILE FOLDER. PLEASE COMPLETE THE QUESTIONS QUICKLY WITHOUT PONDERING LONG-TERM OVER THEM. YOUR INITIAL REACTION (ANSWER) IS PROBABLY THE CORRECT ONE.

COMPLETE THE POST-TEST BY FILLING IN THE BLANKS IN THE SAME MANOR USED FOR THE PRE-TEST.

WHEN YOU HAVE FINISHED ALL OF THE TASKS AND THE POST-TEST (I.E. YOU HAVE COMPLETED ALL OF THE FILE FOLDER TASKS), OPEN THE DOOR AND LET ME KNOW. I WILL BE WORKING JUST OUTSIDE OF THE DOOR.