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The Effect of Color on a Controlled Accuracy Test

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THE EFFECT OF COLOR ON A CONTROLLED ACCURACY TASK

An Abstract of a Thesis

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

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ABSTRACT

Human behavior is influenced by the environment and color is one ever present factor in the environment. Consequently, the impact of color on performance cannot be ignored. Previous research on the effect of color on a fine motor skill has not been systematic and results are inconclusive. The purpose of the present study, then, was to examine the effect of color (green, blue, red, and white) on the performance of a controlled target accuracy task (dart throwing). Based on previous literature, it was hypothesized that color would have an effect on performance. The experiment took place in the Psychomotor-Behavior Laboratory in the University of Northern Iowa. The subjects' (N = 63) mean age was 21.31 (SD = 1.97) years, with a range of 19 to 30 years. The order of testing conditions, determined randomly, was green (Group A); blue (Group B); red (Group C); and white (Group D). The four conditions were assigned to subjects as they entered the laboratory for testing. The color of the target, the darts, and the experimenter's shirt were determined by the color condition for each subject. Subjects were given 6 trials for practice and 6 trials for scoring. After performance testing, subjects completed the

Ishihara Color Blindness Plates (1980) for testing color perception. The distance between the center of the target and the point each dart made was measured in mm. One-way ANOVA results indicated there were no significant differences between the means of the four groups, F (3, 58) = .606, p > .05. Future research should be focused on the amount of color exposed to subjects during testing and the number of trials and/or time required for testing.

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has been approved as meeting the thesis requirement for the Degree of Master of Arts

4/6/00 — Date — Dr. Sharon Huddleston, Chair, Thesis Committee

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CHAPTER I

INTRODUCTION

According to Etnier and Hardy (1997), human behavior is influenced by the environment and one ever present factor in the environment is color. Goldstein (1942) has stated that one cannot overlook the impact of colors on our emotional condition and physical condition. Color, for example, is one of the most important factors in the design of new prisons, hospitals, companies, and schools (Etnier & Hardy, 1997).

According to the Basic Color Theory by Barkey (no date), colors have an energy that influences positive and negative physical states. For example, the color red has been found to lead to greater eye fatigue than the color blue. Also, red has been found to be the most exciting color, green was the most restful, and blue was the most cheerful. In addition, color has been found to affect emotion and feelings, especially, physiological arousal (Barkey, no date).

The relationship between color and human behavior has been studied. Wilson (1966) found from Galvanic Skin Resistance (GRS) data that the color red induced higher arousal levels than the color green. Later, Jacobs and

Hustmyer (1974) found that certain colors had a significant effect on GSR, for example, the color red solicited significantly higher arousal levels than the other colors. Jacobs and Suess (1975) found that subjects exposed to either the red or the yellow screen had significantly higher anxiety levels compared to the subjects exposed to the blue or the green screen. Based on the research, it has been shown that color does have an effect on human behavior. Specially, red induces higher arousal levels and anxiety levels than green, yellow, or blue.

The relationship between human behavior and the environment has also been studied in relation to physical performance and athletic situations. The environment of athletic conditions is important as well as the physical and mental condition of athletes in order for them to give their best performance. Although there are various factors that are considered important in the athletic environment, color must be considered one of the most important (Mahnke, 1981).

Many studies have been done regarding the effect of color on a physical performance under different conditions. Various tasks (cognitive and motor) have been employed in the studies. With a motor skill, motor control is required

and the quality of the movement is the key to success (Schmidt, 1991). On the other hand, with a cognitive skill, decision making is required and the motor control element is minimized. A motor skill can be classified as either a gross motor skill or a fine motor skill

According to Cox (1994), a gross motor skill requires large muscle involvement and a fine motor skill requires delicate muscle control. The types of motor skills that have been mainly investigated are gross motor skills and fine motor skills with or without a cognitive component.

Some research indicates that color has an effect on a strength task (gross motor skill). In Green's (1982) study, when subjects looked at a red wall, they had significantly higher scores on a grip strength task than subjects who looked at a blue or pink wall. In the O'Connell, Harper, and Andrew's (1985) study, subjects performed better when they were looking at the red wall than the green wall. Pellegrini and Schauss (1980) found subjects performed better on a grip strength task in front of the blue board than the pink board. Pellegrini, Schauss, and Birk (1980) found that subjects performed a leg strength task better in front of the blue board than the pink board. From the results, it is clear that red

induced better strength performances than blue, pink, or green, and blue induced better performances than pink.

Research has also been focused on the relationship between color and performance of a fine motor skill with or without a cognitive component. James and Domingos (1953) found that there were significant group (normal and clinically abnormal subjects) differences on the Tweezer Dexterity test. Subjects in both groups had more finger tremor under the red light condition than the white light condition. Nakshian (1964) found that subjects performed significantly better under a green condition than under the red condition on the Hand-Tremor task and the Motor-Inhibition task. However, there was no significant difference between an achromatic condition and a red or green condition. Eason and Smith (1980) found that performance on a dart throwing target task was better using the White-achromatic target than the Multi-choromatic (orange, blue, yellow, green, and red) target. Sage, L. A. (1987) found that intercollegiate basketball athletes' field-goal shooting accuracy was higher on a target rim (neutral) than on the regular rim (orange). Kwallek, Lewis, and Robbins (1988) found that subjects who moved from a blue office to a red office made the most typing

errors. In addition, females who moved from a blue office to red office made more typing errors in the red office than the other groups.

Overall, research is in agreement concerning the effect of color on a gross motor task (strength). However, the relationship between color and performance on a fine motor skill with or without a cognitive component is conflicting.

In most of the studies conducted (Eason & Smith, 1980; James & Domingos, 1953; Kwallek et al., 1988; Sage, L. A., 1987) researchers employed only two colors for comparison and there was no consistency between studies in the colors selected. Also the research has produced no consistency in results. It would be appropriate to examine the effect of all the colors which researchers of various studies have found to have the greatest effect on the performance of a fine motor skill. Therefore, it was the purpose of the present study to test the effect of four colors (green, blue, red, and white) on the performance of an accuracy task (dart throwing). It was hypothesized that color would have an effect on the performance of an accuracy task.

Significance of the Study

Athletes are exposed to many different colors in the competitive environment. For example, green and blue are very popular colors for tennis courts as well as surface for running track. Brownish red is usually the color for outdoor tracks and indoor tracks are usually blue or green. Orange is used for a basketball rim for high visibility. Since color has been shown have an effect on strength tasks (Green et al., 1982; O'Connell et al., 1985; Pellegrini & Schauss, 1980; Pellegrini et al., 1980) and fine motor skills with or without a cognitive component (Eason & Smith, 1980; James & Domingos, 1953; Kwallek et al., 1988; Nakshian, 1964; Sage, L. A., 1987) it is important that the selection and use of colors used in the athlete environment be research based.

The present study attempted to clarify the relationship between color and performance on a fine motor skill. If coaches and athletes could know which color might have the greatest effect on performance, they could use the color in the competitive environment to help improve performance.

Assumptions

The following assumptions were made for this study.

1. The target task was a valid test of accuracy.

2. Based on previous literature, green, blue, red, and white were appropriate colors to examine the research question.

3. All subjects understood and followed the instructions.

4. All subjects were equally motivated to perform their best on the target task.

Limitations

The following limitations are identified for this study:

1. Subjects may not have perceived colors accurately.

2. Laboratory conditions may not generalize to applied settings.

Definition of Terms

The following terms were defined for the purpose of the present study:

Arousal refers to a physiological and psychological level of activation that ranges from comma or deep sleep to excitement (Weinberg & Gould, 1995).

Anxiety is a negative emotional state that is typified by feelings of nervousness or worry (Weinberg & Gould, 1995).

Cognitive skill/task requires decision making as well as the minimization of motor control (Schmidt, 1991).

Color blindness is a condition in which people have problems with color discrimination and in identifying the number of colors displayed (Trevor-Roper, 1974).

Fine motor skill/task requires the involvement of the small muscle in the body (Cox, 1994). Fingers and hands are used to perform as well as eye-hand coordination (Sage, G. H., 1977).

Galvanic Skin Resistance is a measure of increased activation of the surface of the skin (Schlosberg, 1954; Shepherd, No date).

Gross motor skill/task requires the involvement of the large muscles in the body (Cox, 1994).

Motor skill/task is the maximization of motor control and the quality of the movement is the key to success (Schmidt, 1991).

State is a momentary emotional condition (Cox, 1994).

Target task is a dart throwing test of accuracy.

CHAPTER II

REVIEW OF RELATED LITERATURE

The purpose of the present study is to examine the effect of color on performance. The review of literature is organized as follows: research on color and human behavior; color and performance on a gross motor skill; color and performance on a fine motor skill with or without a cognitive component.

Color and Human Behavior

The relationship between color and human behavior has been studied from numerous perspectives. Mahnke (1981) reported color is a critical factor of the design process for architects and interior designers. Color must be considered as an important part of the environment but it is not yet completely understood.

Goldstein (1942) studied the influence of various colors on the physical and emotional conditions of clinical male patients. Although there was no specific information about the study, the effect on color on the deviation of patients' arms was examined. The patients who were seated on a chair were asked to extend their both arms in front of the body and a board was placed horizontally over the arms. Then the patients were asked to close their eyes. When the

patient's eyes were closed, the left arm was deviated 70 cm laterally from the midline of the body. The experimenter placed colored (white, red, yellow, blue, and green) papers in front of patients and asked patients to open their eyes to stare at the paper. Results showed that when the patients were shown the white paper, the deviation was 45 cm from the midline, 50 cm for red, 55 cm for yellow, 42 cm for blue, and 40 cm for green paper. Goldstein (1942) concluded that red would be the emotional stimulus for performance and green would create a situation for action to occur.

Wilson (1966) investigated the relationship between arousal level and color by using a Lafayette 601A psychogalvanometer and Beckman biopotential skin electrodes. Twenty subjects (10 males and 10 females), aged 18 to 25, were seated in front of a colored screen and randomly shown 10 translucent screens (5 red and 5 green). Skin resistance was measured by attaching the Galvanic Skin Resistance (GSR) instrument to the center of each subject's palm. Each trial took 12 s to measure the GRS after a slide was shown. The conductance level was measured by taking the mean of 5 conductance trials (12 s intervals) for a total of 60 s.

As a result, both the conductance level and the GSR data showed that the mean for the red scores was higher than the mean for the green scores. Therefore, the red slides induced higher arousal levels in the subjects than the green slides.

Jacobs and Hustmyer (1974) also examined the relationship between arousal levels and color. The subjects were 24 male college students. The mean age of the subjects was 20 years, with a range of 17 to 27 years. The researchers measured GSR, heart rate, and respiration while subjects were shown red, yellow, green, and blue slides. GSR was measured from the dorsal and ventral surface of the right middle finger for 15 s from the moment the slide was shown. Heart rate was measured by using a photo-plethysmograph attached to the finger on the left hand for 30 seconds. Respiration was measured by the thermistor placed the right side of the nose for the first 30 seconds. The subjects were seated in front of the white slide for 10 min followed by each colored slide for 1 min with a 1 min interval of the white slide in between.

Results indicated that only the GSR data showed significant differences between colors. Red was the most arousing color followed by green, yellow, and blue. There

were also significant differences between red and blue, green and blue, and red and yellow. However, there was no investigation regarding differences between red and green.

Jacobs and Suess (1975) used the same colors as Jacob and Hustmyer (1974) and examined the effect of four colors on the anxiety levels of 40 subjects (13 males and 27 females). The mean age was 19.2 years, with a range of 17 to 29 years. The subjects were randomly assigned into 4 treatment groups. Each subject was seated in front of a colored screen (red, yellow, green, or blue) for 5 min and then completed the State-Trait Anxiety Inventory. The subjects performed 3 trials.

The results demonstrated that the state anxiety scale (A-state) of the State-Trait Anxiety Inventory was significantly higher in both the red and yellow conditions than in the blue and green condition. In addition, these results indicated that red and yellow were related to high anxiety and both green and blue were related to low anxiety. The results supported the Goldstein (1942) findings that found red and yellow to cause more deviation of the arms than either green or blue. Also, the results supported the Wilson (1966) finding that red induces significant high arousal level than green.

Based on previous literature, it is clear that colors have an effect on human behavior, especially arousal and anxiety. Moreover, red induces higher anxiety and arousal levels than green, yellow, or blue. It is interesting to note, however, that gender differences have not been investigated in this area.

Color and Performance on a Gross Motor Skill

Many studies found that color has an effect on strength tasks. Pellegrini and Schauss (1980) studied the effect of color on the muscle strength of 72 right-handed undergraduate students (36 males and 36 females). Subjects were asked to squeeze the Lafayette Hand Dynomometer as hard as possible. The subjects were shown a pink or a blue board (18 x 24 in.) 60 s before and during performing the task. Half of the subjects of each gender were shown the pink board first, and then the blue board for the second trial. The other half of the subjects of each gender was exposed to the colored boards in the opposite order. The results showed that the subjects performed better when in the blue condition than when in the pink condition. Also, male subjects demonstrated a higher strength level than female subjects regardless of the color.

Pellegrini et al. (1980) examined the effect of different visual stimuli hues on the leg strength of 60 collegiate males. A tensiometer was used to measure right leg extension. The experimenter showed the subjects a colored board and asked them to stare at it for 60 seconds. Then the subjects were asked to extend their right leg for as long as possible. After the trial, subjects were asked to rest for 60 seconds. Trial two was the same task using a different color of board. For half of the subjects, the pink board was shown first followed by the blue and then a blue-pink order was used for the other half of the subjects. Results indicated that the scores were higher when subjects stared at the blue board than when subjects stared at the pink board. The results confirmed those of the Pellegrini and Schauss (1980) study.

O'Connel et al. (1985) examined the relationship between grip strength and color. Forty male undergraduate students were randomly assigned into two groups. The subjects were asked to stare at a colored wall for 60 s and then asked to squeeze a hand dynamometer with the preferred hand. Two trials were given and the mean of the two trials was recorded by the experimenter. After a 60 s rest, the subjects were asked to repeat the same procedure in a

different colored room. One group of subjects stared at a red wall first followed by the green wall. The other group of subjects stared at the green wall first. Results indicated that the scores were significantly higher when the subjects were looking at the red wall than when subjects were looking at the green wall, regardless of order.

Green et al. (1982) tested the effect of color on the performance of three different types of tasks. The tasks were grip strength, vertical jump, and the rotary pursuit. Thirty volunteers were asked to perform three trials of each task. None of the subjects were color-blind and none had any experience on the rotary pursuit task. The procedure was not clearly explained but it is assumed that the subjects were shown an illuminated wall before the trial. The colors were red, blue, and pink and randomly ordered for the subjects.

The results demonstrated a significant difference for the effect of color on the grip strength task. The mean score was significantly higher when subjects looked at the red wall than the subjects looked at the blue or pink wall before their trial. However, there was no report for the effect of color on the vertical jump or the rotary pursuit.

The result supported the O'Connel et al. (1985) finding that red conditions led to a significant better performance than green conditions on the grip strength task. Moreover, Green et al. (1982) found no significant differences between the blue and pink conditions. This finding conflicted with both the Pellegrini and Schauss (1980) and that Pellegrini et al. (1980) findings that blue conditions were significantly better than pink conditions on a strength task. Unfortunately, the authors failed to report the gender of the subjects, therefore, it is impossible to determine if gender was controlled.

Based on previous literature, the effect of color on the performance of gross motor strength tasks remains unclear. Blue conditions resulted in better performances than pink conditions, and red conditions resulted in better performances than green, blue, and pink condition.

Color and Performance on a Fine Motor skill With or a Without a Cognitive Component

James and Domingos (1953) tested the effect of color on the performance of a fine motor skill for 96 subjects. The task was the O'Conner Tweezers Dexterity test, the Mirror-Drawing test, and a Finger Tremor test. The normal group was composed of 34 males and 16 female college students. Subjects in the normal group had not received any treatments for mental illness. The abnormal group consisted of 25 males and 21 females that had mental illness for four to six years and were patients at the Milledgeville State Hospital. For the Mirror-Drawing test, only 20 subjects were tested for the abnormal group due to subject mortality. A table (5 x 3 ft.) was placed in the center of a dark room. One condition involved the use of a white 60-watt bulb to give off white light and the other was a 100-watt bulb with deep red filter to give off red light. The table was covered with white cardboard and a piece of white cardboard was placed upright on the back edge of the table to limit the visual field. The subjects were then given the Tweezer Dexterity test, the Mirror-Drawing test, and the Finger Tremor test. For each task, half of the subjects in each group were tested under the

red light first and the white light second. The order of light for the other half of the subjects was reversed.

The Tweezer Dexterity test required subjects to place a pin in a hole on the board as rapidly as possible. Performance was determined by the number of the pins which were placed in the holes. The subjects were tested for two minutes under the each light condition (red and white).

The Mirror-Drawing task required subjects to draw a star without watching their hands or looking at paper. Subjects, however, were allowed to look at the star outline in a mirror and attempted to follow it without touching the sides of the lines. Subjects were required two trials and the time limit for each trial was eight minutes. The time to complete the task was recorded in seconds. The number of errors was counted when the subjects touched the line or crossed it.

Finally, each subject was tested on the Finger Tremor for 30 s under the each light condition. The finger tromometer was placed in front of the subjects. The subjects placed the right middle finger in the loop of the tromometer and tried to hold the finger as stable as possible. The movement was measured in mm for three directions.

On the Tweezer Dexterity test, there were no significant differences in performance within each group under either light, however, there was a significant difference between groups. The normal group performed significantly better than the abnormal group under both lights. On the Mirror-Drawing test, there was no significant difference between groups under either light. Finger tremor results indicated that there was significantly greater finger tremor under the red light than the white light for normal group. The abnormal group had significantly greater finger tremor under both lights than normal group. Overall, even though significant differences were reported, there was no statement of provability in this study. The results are confounded, however, by the uncontrolled variable of gender.

Nakshian (1964) based research on Goldstein's (1942) study of color and performance. Nakshian (1964) hypothesized that performance of fine motor task would be better under a green condition than under achromatic (gray) and red conditions as well as better under achromatic than under red conditions. Nakshian (1964) tested 24 male and 24 female volunteers (18 to 30 years of age) who were given a color-blindness test prior to the experiment. The

subjects performed eight different tasks under three conditions in a counter-balanced design. The three conditions were as follows: (a) R (red), A (achromatic), G (green); (b) RGA; (c) GAR; (d) GRA; (e) ARG; and (f) AGR. This six-color order was used eight times in the experiment for each subject. The experimenters used gray as the achromatic color. The experimental tasks were the Hand-tremor task, the Tweezer-dexterity task, a Judgment-of-length task, a Judgment-of-time-intervals task, a Most-comfortable-position-of-the-arms task, an Outward-movement-of-the-arms-over-a-specified-distance task, a Speed-of-outward-and-inward-arm-movement task, and the Motor-inhibition task.

The Hand-tremor task required subjects to hold the point of a stylus in the hole of the metal plate and to make as little contact with the sides of the hole as possible. The hole on the plate was 2.8 mm and the plate was covered with a color board. The subjects were allowed to practice for 15 s prior to the first trial. Each trial was 15 s and two trials were given with a 30 s rest interval. The total time of contact with the sides of the hole were recorded by an electric clock as a hand tremor. The score was the mean of two trials, in seconds.

The purpose of the Motor-inhibition task was to trace a half circle from left to right as slowly as possible with the stylus. The instruments had a rectangular center piece (8.5 x 5 in.) and were cut in a half circle with a 3.5 in. diameter and 0.25 in wide groove in the half circle. The subjects were required to perform two trials for each condition. The mean of two trials was recorded in seconds.

Results from the Hand-tremor task showed that tremor occurred significantly more under the red condition than under the green condition. Subjects were also faster on the Motor-inhibition task under red than under green condition.

Moreover, the results of the Tweezer Dexterity task showed no effect of color on performance. These results were similar to those of James and Domingo (1953). In addition, the results of the Hand-tremor task supported the James and Domingo (1953) study, which showed that subjects had more finger tremor under the red light condition than the white light condition. Therefore, the hypothesis was partially supported.

The fine psychomotor coordination tasks (hand-tremor and motor-inhibition) were performed better under the green condition than the red condition. On the other hand,

results indicated no significant difference between the red or green condition and the achromatic condition. This finding conflicted with those of James and Domingo (1953), since they found significant differences between the red and white conditions. As in the James and Domingos (1953) study, the effects of gender were not controlled or tested. Based on these results, then, no conclusive statements can be made regarding the effect of color and gender.

Eason and Smith (1980) examined the effect of achromatic and multi-chromatic targets on dart throwing performance. The subjects were 56 volunteer male college students. The mean age of subjects was 20.5 years with a range of 17 to 25 years. The dart board was 4 x 4 ft. and painted with the appropriate colors with a 4 in. wide band for each color. The color of the achromatic target was white with a 1/8 in. black dividing line. The colors for the multi-chromatic target were orange for the center followed by blue, yellow, green, and red. The darts were also blue, yellow, green, and red, that is, 24 with six darts for each color. The subjects were randomly assigned into four treatment groups: white target-white darts; white target-multi colored darts; multi colored target-white darts; and multi colored target-multi colored darts. The

subjects were asked to use an overhand motion standing 20 ft. away from the target. Subjects were given 24 practice throws followed by throws 24 that were scored. From the center of the target to the outer ring, points were scored 5, 4, 3, 2, and 1. The colored darts were ordered 1 blue, 1 yellow, 1 green and 1 red with the order rotated for all 24 darts. Overall, the performance of subjects was significantly better for the white achromatic target condition than for the multi-chromatic target condition. The results supported the James and Domingo (1953) study that also found that the subjects performed better under the white light.

Sage, L. A. (1987) investigated the effect of target rim color on basketball shooting. The subjects were from a university men's basketball team and athletes from the 10 other teams that the home team encountered during one season. One basket rim on the home court was painted a neutral color and another rim color was orange. The attempted free throws and completed free-throws as well as the field-goals were scored during the university team practice sessions and the 10 games. The 10 visiting teams were also scored during the games. The finding showed that the combined free-throw and field-goal shooting accuracy

during practice demonstrated that accuracy was higher for the neutral color rim than for the orange rim. In addition, overall shooting accuracy of the university team and 10 visiting teams to the neutral color rim was significant higher than to the orange rim on field-goals. The findings were similar earlier research results. James and Domingos (1953) found finger tremor occurred more under the red condition than the white condition. Eason and Smith (1980) also found that the subjects performed better on a white target than on the multi-chromatic targets on a dart throwing task.

Kwallek et al. (1988) examined the differences between red and blue offices on mood and a typing task. The total number of subjects was 36 and subjects were paid $7.50 per hour for the 2-hour experiment. Typing errors were counted on the carbons even though subjects made corrections to the document. The number of words typed, typing errors, and answers on the Eight State Questionnaire were measured. Subjects' age was categorized as follows: 18 to 25; 26 to 35; and, 36 or older. Equal numbers of males and females consisted each age group. The subjects' typing skills were categorized as being low (15 to 30 words/min), medium (30 to 45 w/min) or high (45 to 60 w/min). Subjects were

matched by age and typing ability and assigned into four groups. Each group was tested under four different conditions. Those conditions were red office (for both trials), blue office (for both trials), red office for the first trial then the blue office for the second trial, and blue office for the first trial then the red office for the second trial. The subjects were given three different types of business forms (a gift processing form, a purchase voucher, and a request for appointment form) to type. If the subjects were able to finish typing all three forms within the time allowed, an essay was given to them to type. All four walls of the office were painted either red or blue. The subjects were given 5 min of practice then the typing task for 20 min. Following the typing task the Eight State Questionnaire (form A or B) was administered. The Eight State Questionnaire consisted of 8 categories: anxiety; stress; depression; regression; fatigue; guilt; extroversion; and arousal. After a 5 min rest, the subjects came back to the same-colored or different-colored office and repeated then the procedure.

Results indicated that there was a significant difference for typing errors. The groups, which moved to a different-colored office made significantly more errors

than the groups which returned to the same-colored office. Also, the group that was tested in the blue office and then moved red office made more errors compared to the other three groups. Moreover, the females who went from the blue office to red office made more errors than the other three groups, especially on the second trial. Fatigue score for the Eight State Questionnaire were lower on the second trial for the females who went from blue office to red office. Therefore, errors on the second trial for the females were not related to fatigue. There were no significant group differences for scores on the Eight State Questionnaire.

There have been a few studies that did not find an effect for color on the performance on a fine motor skill with or without a cognitive component. In the Green et al. (1982) study, significant differences were found for color only for the grip strength task (not for vertical jump or rotary pursuit).

Goodfellow and Smith (1973) used 125 college students to examine the effect of color on the pursuit rotor and a dexterity task. The rooms were painted red, green, blue, yellow and gray. The subjects were randomly assigned to the five color conditions. Result demonstrated that there

was no significant difference in performance between the five conditions on either task.

Ainsworth, Simpson, and Cassell (1993) examined the effective of color on mood and a typing task. Forty-five female college students (18 to 24 years) were randomly assigned to a red, blue-green, or white office and given a typing task for one hour. In addition, anxiety, depression, and arousal were measured by using the Eight State Questionnaire. The result showed no significant differences between the three groups on performance or mood. The results contradicted those of Kwallek et al. (1988) who found significant differences for color on performance. However, the results partially supported Kwallek et al. (1988) study which found no significant differences between groups on mood.

Etnier and Hardy (1997) examined the effect of color on performance. The volunteer subjects were 13 male and 17 female college students. Their mean age was 18.57 years, with a range of 18 to 20 years. Subjects performed the Wingate Anaerobic Test (gross motor skill) and the McCloy Block Test (fine motor skill) in green, orange, and white rooms. The results indicated that the color of the room

had no effect on either the gross motor skill or the fine motor skill.

Summary

In conclusion, color must be considered as an important factor in the environment (Mahnke, 1981; Goldstein, 1942). Researchers have investigated the effect of color on arousal levels (Jacobs & Hustmyer, 1974; Wilson, 1966) as well as on anxiety levels (Jacobs & Suess, 1975). Based on the literature, some conflicting results have been found. Both Wilson (1966) and Jacobs and Suess (1975) found red induces significant higher arousal and anxiety levels than green. However, Jacobs and Hustmyer (1974) found no significant difference between red and green on arousal level.

Many studies have been done regarding the effect of color on a gross motor skill (strength task). Based on the literature, it is clear that blue induces better performances than pink (Pellegrini et al., 1980; Pellegrini & Schauss, 1980) and red induces better performances than blue, pink, or green (Green et al., 1982; O'Connell et al., 1985). On the other hand, Green et al. (1982) found no significant difference between blue and pink conditions.

Research on the effect of color on a fine motor skill with or without a cognitive component has been done under many different conditions. White conditions were found to be better than red conditions for performance on the Finger Tremor test (James & Domingos, 1953), and green conditions were better than red conditions on the Hand-tremor and the Motor-inhibitation tasks (Nakshian, 1964). However, since Nakshian (1964) study showed no difference between achromatic (gray) and red or green, the results conflict with the James and Domingo (1953) study which found significant differences between red and white. Moreover, it was found that white or neutral conditions were better than multi-chromatic or orange conditions on a dart throwing task and a basketball shooting task (Eason & Smith, 1980; Sage, L. A., 1987). In addition, it was found that subjects moved to the different-colored conditions (blue office to red office or red office to blue office) made significantly more errors than subjects who returned to the same-colored (blue and red) office (Kwallek et al., 1988).

The literature is not in total agreement. Some studies found no effect for color on a gross motor or a fine motor skill with and without a cognitive component.

For example, research designed to test the effect of color (blue, blue-green, gray, green, orange, pink, red, white, and yellow) on various tasks have found no significant difference (Ainsworth et al., 1993; Etnier & Hardy, 1997; Goodfellow & Smith, 1973; Green et al., 1982). Therefore, there have been inconsistent finding regarding the effect of color on both tasks/skills.

Even though some researchers have found an effect for color on the performance of a fine motor skill with or without a cognitive component, several points require further investigation. For example, many researchers investigated only two colors (Eason & Smith, 1980; James & Domingos, 1953; Kwallek et al., 1988; Sage, L. A., 1987) and there was no consistency between studies in the colors selected for testing or in the results. It is, therefore, very difficult to know which color has a greater effect on the performance of a fine motor skill with or without a cognitive component. Overall, various studies indicate that four colors (red, blue, green, and neutral) may have an effect on performance of a fine motor skill. In attempt to clarify research findings, therefore, the effect of green, blue, red, and white (neutral) conditions on a fine

motor skill (accuracy component) will be investigated in the present study.

CHAPTER III

METHODS

The purpose of the present study was to examine the effect of color on the performance of a fine motor skill. Based on previous literature, it was hypothesized that color would have an effect on performance.

Design of the Study

The present study utilized a true-experimental design. The independent variable was color (green, blue, red, and white). The dependent variable was performance on a controlled target accuracy task.

Subjects

Subjects were recruited from two Psycho-Social Aspects of Physical Activity and Sport classes at a mid-western university and were given credit for their participation in the study. Participation in the study was one of four options students had for extra credit in the course. Conditions were assigned to subjects after they signed up for the study. Seventy-eight male subjects were examined and 15 subjects' data were eliminated because they failed to pass the color blindness test, used a non-dominant hand, or wore tinted glasses during testing. The subjects' (N =

63) mean age was 21.31 (SD = 1.97) years, with a range of 19 to 30 years.

Instruments

Subject Demographics

The subject demographics sheet was used to obtain information. The subjects provided their age and preferred handedness (Appendix A).

Color Blindness Test

The Ishihara Color Blindness Plates (1980) were ordered from Lafayette Instruments, however, reliability and validity information was not available. In addition, the information was not found in the literature through a search on the PsycINFO CD Rom or The ERIC database CD Rom available in the library.

Task

A dart throwing target task was utilized to test controlled accuracy. The bulls eye on the target was a 3 cm solid black circle that was placed in the center of a sheet of colored paper (120 cm x 120 cm). Four colors (green, blue, red, and white) of paper were used for the targets. The targets were placed on a wall that was covered with 2.5 cm thick Styrofoam sheet. Based on the American Dart Organization Tournament Rules (1996), the

targets were placed 1.70 m from the center to the floor. The darts used by the subjects were painted the same color as the target for each condition. A new target was used for each subject. The distance between the center of the target and the point each dart made was measured in mm. Based on the American Dart Organization Tournament Rules (1996), subjects stood behind a throwing line that was placed on the floor 2.30 m from the target.

Procedures

The experimenter entered two classes to request volunteers. The experimenter informed students that the purpose of the study was to collect college-age performance norms for a laboratory accuracy task and a visual perception task. Students were informed that they could cease participation in the study at any time without fear of reprisal. Subjects' names were requested only for the purpose of assigning extra credit. Subjects were also informed that their names would not be entered into the computer for data analysis.

Testing conditions were assigned as the subjects entered the laboratory for testing. The time of testing for each subject was determined by the subjects' schedule. The order of testing for the conditions was determined

randomly and was green (Group A); blue (Group B); red (Group C); and white (Group D). Subjects who did not report for their testing time were rescheduled. For the re-scheduled opportunity, subjects were tested under the same condition as was first scheduled.

Testing took place in the Psychomotor-Behavior Laboratory in the University of Northern Iowa. Subjects were tested one at a time and no additional individuals were present during testing. Each subject was given two copies of the informed consent form prior to testing. Subjects were asked to sign and return one copy of the form to the researcher and to keep the second copy for reference.

The experimenter wore the same color of shirt (green blue, red, and white) as the darts and the colored target in each condition. The experimenter read the instructions (Appendix B) to each subject. Subjects were again informed that the purpose of the study was to collect college-age performance norms for a laboratory accuracy task and a visual perception task. Subjects were then given an opportunity to ask questions about the procedures.

The task was an overhand dart throwing task using the dominant hand. Based on previous literature, six trials

for practice and six trials for scoring were given to each subject. After six practice trials, the experimenter covered the holes in the target with colored stickers. The experimenter then informed the subject that the next six trials would be measured. All darts that landed on the target face for the 6 scoring trials were measured in mm from the center of the bull's-eye. The task was performed at the subjects' own pace.

After completion of the task, subjects were asked to take a seat and complete the Ishihara Color Blindness Plates (1980). Each subject was shown the 14 plates and asked to read the number on each plate. A subject was considered to be color blind if their response to 5 or more plates was incorrect. Subjects who were identified as being colorblind were eliminated from the study before data reduction. After the subject exited the laboratory, a new target was put into place and the experimenter changed shirts for the testing of the next subject.

Data Description and Analysis

The task produced ratio level data scored in mm. Data was measured as total of 6 trials. A one-way analysis of variance (ANOVA) procedure was used to test for significant

performance differences between groups (green, blue, red, and white).

CHAPTER IV

RESULTS

The purpose of the present study was to examine the effect of color on the performance of a fine motor skill. Based on previous literature, it was hypothesized that color would have an effect on the performance of a controlled target accuracy task.

The effect of color (green, blue, red, and white) on the dart throwing task was measure by a one-way ANOVA procedure. Results indicated there were no significant differences between the means (see Table 1) of the four groups, F (3, 58) = .606, p > .05. The hypothesis that color would have an effect on performance was not supported.

Table 1

Means and Standard deviations for Total Performance Scores

Group	M	SD	n
Green	382.37	132.22	16
Blue	379.06	104.62	15
Red	410.70	147.55	17
White	353.60	83.79	15
Total	382.38	119.70	63

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of the present study was to examine the effect of color on the performance of a controlled target accuracy task. Based on previous literature, it was hypothesized that color would have an effect on performance. No significant differences, however, were found between groups (green, blue, red, and white) on the darts throwing task. Therefore, the hypothesis was not supported.

Previous research is conflicting concerning the effect of color on a fine motor skill with or without a cognitive component. In most of the studies, researchers employed only two colors for comparison and there was no consistency between studies in the colors selected (Eason & Smith, 1980; James & Domingos, 1953; Kwallek et al., 1988; Sage, L. A., 1987). Therefore, there is no consistency in the reported findings. In order to rectify the methodological problems from previous studies, the four colors (green, blue, red, and white) which researchers have found the greatest effect on the performance of a fine motor skill were chosen for testing in the present study.

Results of the present study supported earlier studies which found no effect of color on a fine motor skill (Ainsworth et al., 1993; Etnier & Hardy, 1997; Goodfellow & Smith, 1973; Green et al., 1982) and were inconsistent with the studies which found an effect for color on fine motor skills with or without a cognitive component (Eason & Smith, 1980; James & Domingos, 1953; Kwallek et al., 1988; Nakshian, 1964; Sage, L. A., 1987).

It is possible that two factors could account for the different results between the present study and the studies which found color to have an effect on fine motor skills. One is the environmental conditions where subjects were tested and the other is the number of trials and/or time duration of the experiment.

In the present study, the subjects were surrounded by white walls, ceiling, and floor. The only color in the room was that of the target, the darts, and the experimenter's shirt and all three were the same color (either green, blue, red, or white) for each subject. Therefore, even though color was present, the room was predominately white.

James and Domingos (1953) found that subjects performed better under a white condition than a red

condition on the Finger tremor task. The red condition was created by covering a white light with a red filter. For the white condition, a white light was used. Even though the color of the walls and floors was not reported, everything in the subjects' visual field was tinted either red or white. Nakshian (1964) found that subjects performed better the Hand-tremor task and the Motor-Inhibition task under a green condition than the red condition. Even though all apparatus items were painted gray, the walls were painted with red or green. Therefore, the subjects were surrounded by the treatment color. Kwallek et al. (1988) found that the subjects who moved to a different-colored office (specifically, the red to the blue office or the blue to the red office) made more errors than the subjects who moved to the same-colored office on the typing task. For both offices, the walls were painted either red or blue. Again, the subjects were surrounded by the color during the experiment.

On the other hand, subjects were also surrounded by painted walls for the studies which found no effect for color on a fine motor skill. Goodfellow and Smith (1973) found no significant differences between five groups on the pursuit rotor and the dexterity task. The rooms were

painted with red, green, blue, yellow, or gray. Ainsworth et al. (1993) also indicated no significant differences between three groups on the typing task. The offices were painted with red, blue-green, or white. Etnier and Hardy (1997) showed that color had no effect on either a gross motor skill or a fine motor skill. In the study, the walls were pained with green, orange, or white.

In summary, three studies (James & Domingos, 1953; Kwallek et al., 1988; Nakshian, 1964) where researchers surrounded subjects with color found significant differences in the performance on a fine motor skill. However, another three studies (Ainsworth et al., 1993; Etnier & Hardy, 1997; Goodfellow & Smith, 1973) indicated no effect of color in the performance on a fine motor skill. Therefore, whether the factor of the amount of color used for the testing is important or not remains unclear.

Another possible explanation for the present findings may be related to the number of trials used (6 for practice and 6 for scoring). The number of trials determined the time duration that subjects were exposed to the color condition. In this study, the time period for exposure was average 5 min.

On the other hand, studies which found an effect for color on fine motor skills either used more trials and/or required that subjects stayed longer in the condition. Eason and Smith (1980), for example, found that subjects performed better on the white target than on the multi-colored target. The subjects had 24 practice trials and 24 scoring trials. Sage, L. A. (1987) found that field goal accuracy for a neutral color basketball rim was significantly higher than for the orange rim. The experimenter collected data for 10 games on two teams. Therefore, subjects were exposed to the color rims for an entire game. Finally, subjects performed a 2 hour typing task in an office with colored walls in the Kwallek et al. (1988) study.

Other researchers who found no effect of color on a fine motor skill also exposed subjects to color for a longer period of time than in the present study. Goodfellow and Smith (1973) tested subjects with four 3 min trials and 10 sec rest between each trial on the pursuit rotor task. Following the pursuit rotor task, subjects were given the dexterity task. It is assumed that testing took about 20 min to complete for each subject. In the Ainsworth et al. (1993) study, subjects performed a typing

task for an hour. The authors explained the time duration was not long enough to measure the effect of color on performance. In addition, the authors recommended that subjects be examined for eight hours or for more than one day. Etnier and Hardy (1997) discussed that a longer duration of testing might affect significant influence of color to performance. There is no information about time duration, however, the subjects had three testing days and it is assumed each testing session took 10 to 20 min.

It appears, then, that subjects had more trials and/or were required to remain longer in the treatment condition than the present study in the three studies (Eason & Smith, 1980; Kwallek et al., 1988; Sage, L. A., 1987) which found an effect for color on a fine motor skill. However, three other studies (Ainsworth et al., 1993; Etnier & Hardy, 1997; Goodfellow & Smith, 1973) that found no effect for color on a fine motor skill also utilized more trials and/or required subjects to remain longer in the treatment condition than in the present study. Therefore, the importance of the number of trials and/or time duration of the testing also remains unclear. Future research, then should be developed to investigate the environment for

testing and the number of trials and/or the time required for testing.

Finally, the sample size should be considered for future research. In the present study, the number of subjects in each group were fairly low. The large standard deviation of the performance score in the present study also supports the necessity of a larger sample size.

If future research leads to consistent findings, it may help coaches and athletes structure the best environment possible for performances. For example, coaches might want to consider the colors used in the opponent's and the home teams locker rooms and the color of athletes' uniforms. In addition, coaches might want athletes to stare at a specific color prior to a game or a race depends on performance. For example, athletes could bring a colored poster board and stare at it various times during a trip or prior to a game. The literature indicated that color had an effect on strength tasks (Green et al., 1982; O'Connel et al., 1985; Pellegrini et al., 1980; Pellegrini & Schauss, 1980). Pellegrini and Schauss (1980) found that performance on a strength task was enhanced after subjects stared at a colored board for only 60 s.

Their results were also supported by O'Connel et al. (1985) and Pellegrini et al. (1980).

Overall, the literature is clear that color has an effect on a gross motor skill (a strength task) but not on a fine motor skill. Certainly, the potential uses for color in the athletic environment should be further explored.

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APPENDIX A

Subject Demographics Sheet

Appendix A

SUBJECT DEMOGRAPHICS

Please answer the following statements in order to provide information for statistical purposes:

Age: _____

Prefer Handness (circle one):

R L

APPENDIX B

Instructions

Appendix B

INSTRUCTIONS

1. As the subjects enter the laboratory: "Hello. What is your name?" Put subject number and group on the subject information sheet.

2. "My name is Kaori. I am interested in collecting college age norms for a laboratory accuracy task and visual perception task. Please have a seat here, read and sign this informed consent form and complete these two questions on the subject information sheet."

3. When the subject completes the information sheet: "Please follow me. Please step over here to the line. Your task is to throw 6 practice darts and 6 scoring darts with your dominant hand from behind this line. Try to hit the black center of the target on each throw. Darts within the outside ring will be measured and those outside that ring will not be scored. Do you have any questions? You may now begin."

4. After the subject has completed the task: "Please follow me back in the first room and have a seat. I will give you some plates. Your task is to read the number in the plates as quickly as you can."

5. After the color blindness test: "Thank you for participating my study."

APPENDIX C

Informed Consent Form

Appendix C

INFORMED CONSENT

The purpose of the present study is to collect college age performance norms for the accuracy task. You will be asked to complete an information sheet and two laboratory tasks. There is no risk or discomfort associated with either task. Your participation in the present study is voluntary and you may cease participation at any time without fear of reprisal.

The investigator for the present study is Kaori Araki in Health, Physical Education and Leisure Service (319/273-5960) department. If you have any questions, you may contact at her . In addition, information about the present study may be obtained from Dr. Sharon Huddleston . Furthermore, information about the research and the right of research subjects may be obtained from the Human Subjects Coordinator, University of Northern Iowa (319/273-2748).

I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement.

_____ _____

(Signature of subject) (Date)

_____

(Printed name of subject)

_____

(Signature of investigator)