The effect of ball color and background color on the striking performance of 1st, 3rd, and 5th graders
by Patricia Teutschman Alomar

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Physical Education
Montana State University

Abstract:
The main purpose of this study was to conduct an investigation on the effects of ball color, and background color on the striking performance of elementary school children. The subjects participating in this study were a total of ninety boys and girls attending grades one, three and five in New York City.

A review of related literature suggested that visual information processing is a highly involved and complex subject. Man reacts to what he sees based on previous experiences and acts as a result of these experiences. Visual perception and motor skills are highly integrated and studies have indicated a direct comparison between vision and performance. Color perception is a vastly complex series of light reflection, environment, emotions and previous experience. There is limited research in regards to striking and perception but the few studies investigated found that performance is influenced by a variety of factors such as ball color, background color, velocity, trajectory and age differences. The degree of these variables is a subject for investigation.

The sequence for this investigation followed a prescribed order in the presentation of the stimulus. A scoring system was implemented to evaluate the striking performance. Each subject was asked to strike a total of thirty balls against two different colored backgrounds with a paddleball racquet. The ball presentation, which was projected by a tested projectile machine, followed this order - blue, yellow and white.

The results of this data were measured by a four-way analysis of variance with two repeated measures, ball color and background color.

A t test was used for a post hoc comparison for the significant main effects. The main effect of ball color indicated that it was an influencing factor upon striking performance. The combination of yellow balls against a white background produced the best performance. It should be noted that the order of presentation could have produced a learning factor which would influence the results in regards to the best combination. Background color was also found to be an influencing factor upon striking performance. The main effects of grade and sex were found to be significant on striking performance.

The results of this investigation verify previous findings concering the effects of visual perception and motor performance.

This research was inconclusive in respect to a perfect color and background combination. It merely suggests that these factors are an influence.

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Date October 28, 1980

DEDICATION

TO R. T. B.

Everyone has an inspiration, a driving force in one's life that makes the difference between achieving and existing. You are my mentor and I love you for that reason.

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ABSTRACT

The main purpose of this study was to conduct an investigation on the effects of ball color and background color on the striking performance of elementary school children. The subjects participating in this study were a total of ninety boys and girls attending grades one, three and five in New York City.

A review of related literature suggested that visual information processing is a highly involved and complex subject. Man reacts to what he sees based on previous experiences and acts as a result of these experiences. Visual perception and motor skills are highly integrated and studies have indicated a direct comparison between vision and performance. Color perception is a vastly complex series of light reflection, environment, emotions and previous experience. There is limited research in regards to striking and perception but the few studies investigated found that performance is influenced by a variety of factors such as ball color, background color, velocity, trajectory and age differences. The degree of these variables is a subject for investigation.

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The results of this investigation verify previous findings concering the effects of visual perception and motor performance. This research was inconclusive in respect to a perfect color and background combination. It merely suggests that these factors are an influence.

Chapter 1

INTRODUCTION

Since the late seventies, America has become more sports conscious and participant oriented than in the previous years. No longer are people content to be only spectators, watching the pros who are so well-coordinated. These same people are often inspired to improve their own movement skills.

Spectators are offered an alternative to the traditional team sports. Lifetime sports such as tennis or racquetball offer opportunities to increase participation, coordination, mental well-being and social interaction as well. This sports movement has not only affected the adult population; our youth has also been inspired by outstanding performances like Nadia Comanechi in gymnastics and Tracy Austin in tennis. The dynamic ability of youth in sports has been demonstrated and serves as an incentive to our nation's youth.

Youth designed programs are increasing throughout the nation in a wide variety of sports. Physical educators have accepted the challenge of a movement oriented society and have made efforts to analyze specific movement tasks which will enhance performance in many different sports.

This investigator is pursuing an interest in factors which involve the movement pattern of striking. Striking a ball involves several variables acting in concert and a close analysis would indicate ball

size, speed, trajectory, ball color and background color as collective elements which would influence performance. Investigators have attempted to research these variables, some in different combinations, in an effort to fully understand the complexity of this basic motor skill of striking.

It has been determined through previous investigations that ball size directly affected the catching performance of young children ages three through seven. Although these studies by Halverson (15) are concerned with the movement task of catching, analogies can be made in comparison to striking because both movement tasks involve the perception of a moving object.

Williams (30) investigated the influence of ball speed, velocity and trajectory upon performance of a catching task and found these factors to have a direct affect upon performance of the catching task. Again, a similarity between the movement tasks of catching and striking could lead to a similar analogy.

Direction of the ball is another influence upon performance. It has been determined that a ball directed at the center of the body is easiest to catch, followed by catching on the preferred side of the performer and then catching on the non-preferred side of the performer has a significant influence on performance of the movement task. This data can again be applied to the movement task of striking because of similarities in motor performance.

Data collected in the mid-seventies by Morris (19) indicated that ball color influenced catching performance and Moran (18) discovered that ball color affects the striking performance of youngsters. The specific combinations of all these factors and their mutual effectiveness have not been determined and may never be, because of the complexity of the problem.

All these external factors influence performance, yet another area that needs to be included in this investigation is the body's ability to interpolate all this information through its own perceptions. Since most of the stimuli is visual information, areas of investigation would include: visual acuity, peripheral perception, color perception and visual field. This study will concentrate on peripheral perception and color perception. Studies have indicated that each of these perceptions either combined or individually has a degree of influence upon performance but to what degree is highly complicated and worthy of further in-depth investigation.

As you can summarize, this is a complex and multi-faceted subject, which is challenging and necessary if we are to be responsible to our youth. Gallahue (10) wrote in his text on motor development and movement experiences that: "The matching of perceptual and motor data is thought by many to be necessary for the child to establish a stable spatial world."

Need for the Study

It is evident from the preceding paragraphs that many areas concerning factors which influence striking have been explored. However, the information concerning the interactions of ball color and background color is still very limited. Does the ball color have an effect on striking performance? What part does background color play in relationship to the color of the ball? Answers are needed so that we may give our youth the best opportunities for developing appropriate motor skills.

Statement of the Problem

The purpose of this study was to determine the effects of ball color and background color upon the striking performance of selected first, third and fifth graders.

Hypotheses

Hypothesis One: It was hypothesized that the color of the ball will have no significant effect on striking performance of first, third and fifth graders.

Hypothesis Two: It was further hypothesized that the color of the backgrounds will have no significant effect on striking performance of first, third and fifth graders.

Hypothesis Three: It was also hypothesized that there will be no significant differences in striking scores between boys and girls.

Hypothesis Four: It was hypothesized there will be no significant differences between the striking scores of the first, third and fifth graders.

Assumptions

It was assumed that the children participating in this investigation were equally motivated to perform the striking skill under the determined conditions. It was also assumed that each subject group for grades one, three and five were representative of a normal range of abilities in regards to developmental norms.

Delimitations

The children participating in the investigation all attended the Lenox School in New York City, New York. The children participating were in the first grade, third grade and fifth grade. The testing covered a one month period during the spring of 1978. The testing was further delimited to the effects of ball color and background color on the striking performance of selected first, third and fifth graders.

Definition of Terms

Background Color: Background colors was defined as two, three by five yard cotton cloths. One was a flat white and the other was a flat black color.

Balls: Balls used were plastic, baseball size which were marketed by the Cosom Company and identified as "Fun Balls."

Ball Color: Ball color referred to three different colors. Each can be identified in the Munsell System with the following values: Blue-5PB5/10. Yellow-5Y8/10. White-reflectance about eight-five percent.

Granada Pitching Machine: A machine which consistently projected balls with a constant velocity and trajectory. It was manufactured by the Bruce Boys Manufacturing Company.

Striking Implement: A wooden paddleball racquet made by the Marcraft Company, model #PT-30.

Striking Scores: A performance scale based on a four point system previously used in the Moran (18) study. It was used to evaluate the striking performance of the subjects.

Chapter 2

A REVIEW OF LITERATURE

The following topics in this chapter will be reviewed in order to fully acquaint the reader with the necessary background information as it related to the topic under investigation. The areas for review were: Visual Information Processes, Visual Perception and Motor Skills, Perception of Color and Striking Performance.

Visual Information Processes

A basic understanding of visual information processing was reported by Barsch (2) and expressed by Emery. He defines it,

> As a process whereby data are received and integrated with other inputs into the brain and with stored information, the meaning is abstracted and the organism institutes the appropriated output whether the output be movement, visualization or projection. After the initial output, there is always some resultant input or feedback through some or many sensory paths, which tell the person whether or not the output satisfied the situation.

What the eye sees involves much more information beyond just looking at an object.

Gregory (14) suggests that visual information processes involves previous knowledge of the object derived from past experiences, and these experiences are not limited to vision. It may include hearing, touching, tasting or smelling.

Objects are far more than patterns of stimulation:

> Objects have pasts and futures; when we know its past or can guess its future, an object transcends experience and becomes an embodiment of knowledge and expectation without which life of even the simplest kind is impossible.

It can be stated that the visual experience is a dynamic phenomena. Arnheim (1) suggests the following:

> What a person or animal perceives is not only an arrangement of objects, of colors and shapes, of movements and sizes. It is, perhaps first of all, an interplay of directed tensions. These tensions are not something the observer adds, for reasons of his own, to static images. Rather, these tensions are as inherent in any percept as size, shape, location or color.

It is apparent that the visual process is a complex chain of interdependent processes. Stimuli from the environment activate the senses, cause neural activity which terminates in a behavior. Singer (26) reported that Berelson and Steiner categorized the process as having a stimuli present, followed by prior learning which influences the learners set or expectations and compounded by the learners' motives. These considerations make the visual information process highly individualized.

Several studies have been done which verify this premise. Ames and Ittleson, as reported by Barsch (2) expressed a view which stated that the world man is related to, that he sees, lives in and that affects him, is the result of a transactional process in which man himself plays an active role. Barsch (2) also reported a study by Cantrill concerning the stimuli received by each eye and the

perception which was derived. He found that the eyes either blended the information together or imposed one over the other. For example, an American and Mexican were shown two pictures simultaneously, the right eye saw a bullfighter, the left eye saw a baseball player. The response as to the identity of the picture was signficant. The American saw the baseball player and the Mexican saw the bullfighter. Therefore, a person sees what is important, with "important" defined by his own relationship to what he sees.

Cratty (6) has determined through his research that one of the central factors which influence perception is the way we select objects from their background and the dependency upon selecting this object when making perceptual judgements. Evans (8) has stated

> We know that some perceptions that appear to be due to the relationship of the stimulus itself are in fact due to the relationship of the stimulus to its perceived environment.

Drowatzky (7), through his investigations, summarizes the characteristics of visual information processing by stating that cues, like size, color, partial overlap, texture, shadow and perspective are highly important in its influence upon motor performance.

The physical aspects of this process are so diversified that physiologists are still researching the sequence of events and will probably do so for a long time. The actual visual process of refracting light rays and focusing on images, transmitting these

rays by nerve impulses, processing this stimulation in the brain and resulting in an associated reflex is very consistent. How the brain proceeds, culminating in perception is another topic to be discussed.

Visual Perception and Motor Skills

As stated above, information which is perceived and analyzed results in an output of information or performance. A motor skill involves the movement of the body or any body parts in reaction to a stimuli, to accomplish a specific task. It can be seen as the end results of a complex chain of information. Literature supports the interrelationship of perception and motor skills.

According to Gavriysky (11), eighty-five percent of man's information is received through his visual properties; that is, visual acuity, central and peripheral vision, depth perception, color vision and movement perception. He states that any or all of these variables may influence sport performance. Singer (26) is convinced that learning and performing motor skills depend on one's perceptual abilities. He reported a study by Bannister and Blackburn which investigated the placement of the eyes and their relationship to skill achievement. They measured the distance between the eyes of college students and confirmed that the superior performing students had a wider eye placement and theoretically better stereoscopic vision.

Herkowitz, as reported by Ridenour (2), has stated that variables

figure prominently in acquiring and performing motor skills. She also states:

> If an instructor is to be successful in helping a child, he must be able to identify such task and environmental variables, understand their interactive influences on performance, manipulate these variables to provide developmentally appropriate and challenging movement experiences.

Whiting (28), in his book concerning ball skills, reports that to fully understand perception in relation to a ball, it is important to realize that the eyes are very sensitive to light and sound energy. The receptors convert this energy into a neural coding and relays the message through the nerves which process and interpret the information. It is the brain that perceives, not the eyes. Psychological literature stresses the importance of vision and how it enhances performance.

In another study by Graybiel (13) concerning peripheral vision, he found that elimination of peripheral vision caused a disturbance in performance. This disturbance in performance was greater than the elimination of central vision or, in some cases, removal of all vision. Other studies have found that an increase of peripheral vision greatly increased performance in the shooting accuracy in basketball. Based on these facts, one can conclude that peripheral vision is important in acquiring skills and increasing performance.

Ross (21) tried to determine if there was any correlation between poor visual perception skills and poor motor performance. The

result of the study showed a positive correlation between many of the variables and what the child did, in regards to motor skill performance, was partially dependent on visual skill. Skovran (27), in her study, tried to determine the ability of five year olds to process visual information and the completion or proficiency of a motor task dependent on visual information. She concluded that no relationship existed between the visual processes measured by the Illinois Test of Psycholinguistic Abilities and a motor task requiring vision for successful completion.

Ridenour (20) investigated the effects of object size, speed and direction on 1) the distance an object must travel before an accurate decision was made and 2) the time to prepare for a movement response after the decision was made. The study concluded that ball speed and direction were definitely determining factors influencing response and performance. Based on these series of studies, one can identify the relationship between perception and motor skills.

The Perception of Color

Color perception, as defined by the Committee on Colorimetry Optical Society of America, is a subjective impression of color which is modified by observational conditions and by the mental interpretation of the objects. This perception is influenced by the indicent of light upon the retina, which results in a conscious response. Schiffman (22) refers to color perception as the capacity to perceive

and differentiate between lights based on their wave length composition.

The color experience of anybody depends upon a variety of contributing factors. The Committee on Colorimetry Optical Society of America (5) reports that,

> Although perception itself is an integrated resultant which need not bear close similarity to any of the factors underlying it, familiarity with these factors is essential to understanding and control of the perceived phenomena.

Some of the factors of color perception are: visual development, normality of the response system, nature of the sensations, stimulated area of the retina, effects of luminance, wave length, purity of the stimulus, time relations, effects of visual adaption to light and color, after images, binocular phenomena, color discrimination, modes of appearance, color consistence, visual attention and color memory. Thus, the perceived color depends on many circumstances and the conditions of the stimulus will affect the name given to a color.

Color is part of the spatial environment and offers an abundance of information. Evans (8) reports that while observing a scene, if one looks at a bright part it will darken and if one looks at a dark part it will lighten, only to enhance the perception of detail and within the physiological limits of the viewer. Audley and Wallis, as reported by Chase (3), experimented on brightness and

pitch and concluded that it was easier to select the brighter of two absolute bright lights and the darker of two absolute dark lights. This supports the observation of Evans (8) that some perceptions that appear to be due to the relationship of the stimulus itself are actually due to the relationship of the stimulus to its perceived environment.

Results from a Gallahue (10) study indicated that a pronounced lack of contrast between a figure and the background may affect the gross motor performance of a child. The ground patterns become distracting, providing an overabundance of stimuli and this diminishes performance and locomotor movement. Audley and Wallis, as reported by Chase (3), in the same experiment previously mentioned, stated:

> Subjects do code comparative judgements on what they perceive to be the underlying dimensions of the stimuli and that the background illumination of the presented stimuli influences what subjects perceive as the underlying dimension.

Since color depends on stimulus wave lengths and intensities, Gaines (9) suggests that it is advantageous to know the chroma, value and hue in order to predict response time and discriminability to any color. In regards to hue discrimination, he found that yellow and orange are the easiest to discriminate, followed by blue and purple with red and green colors being the most difficult to discriminate. In a study by Shick (24), the research suggests color affects the size of an object. Yellow appears to be larger

in comparison to other colors and the size of yellow objects is usually overestimated. Red objects were also overestimated while blue and black were underestimated. Two colors which had neither reaction were green and purple. Shick (24) categorized the visibility of colors in the following order, starting with the most visible to the least. The order is as follows: Yellow, white, red, green, blue and black. In other research by McCain (17) investigating the perception of red and blue, red was consistently overestimated in comparison to blue when subjects were asked to position each color in relation to each other. Red was always perceived closer while blue was perceived to be further away.

Emotional values are often equated with colors. Tests to determine people's reactions to color were administered by Gerritsen (12). This research concluded in regards to heart rate and respiration rate, the red caused a fast occurrence, green is steadier rate and blue a much calmer rate. It was also determined that arithmetic problems viewed in a yellow color produced the least mistakes and blue produced the highest error rate.

Gaines (9) reported that error rate is linear, that is the younger the group, the higher the error. It has been suggested in literature that color perception is developmental in regards to ages. Gaines (9) states in regard to this fact, "The latency data differ with respect to age: adults are slowest, followed by

kindergarteners and fifth graders. High school sophomores are the fastest." Research reported by Gallahue (10) indicated that color was used by five year olds as a tool to identify a given object and form and color was used as a tool for identification by six and seven year olds. Therefore, we can see that color perception is developmental and an influence in performance.

Color perception is a highly complicated subject and is constantly researched because of its variability and the complexity of perception. The fascinating aspect about color perception is the variability between individuals in the stimuli and that which induces them to produce matching colors.

Striking Performance

There has been little research done in the past concerning the perceptual aspects of a striking pattern. This investigator will include some studies which involve the motor pattern of catching due to the similarities in tracking and movement prediction.

Two similar studies done by Morris (19) and Moral (18) investigated the possible correlation of ball color and background color in regards to catching and striking performance in elementary school age children. Both findings concluded that ball color did indeed affect the performance of both catching and striking performance. Morris states:

> ...if one is concerned about using effective teaching procedures and/or methods, then he or she should be aware of the environmental surroundings, ball types, and ball colors because they are influential factors affecting the performance of the catching skill. (19)

Background color was not found to be significant in either study. In the Moran (18) study, the yellow balls were found to produce the highest performance levels and white balls were found to be the least effective.

Seills (23) investigated striking performance in regards to age. He used a pendulum controlled hoop with a ball suspended and as a striking implement a twenty inch bat. The results showed consistent improvement in the mean performance score of boys at successive grade levels. In 1966, Halverson and Robertson (15) studied the development of sidearm striking. A ball was tossed or suspended at waist level and projected with a force in the subject's direction. Attempts were filmed at intervals which showed developmental changes. It was found that when the task was changed, striking patterns regressed to former stages.

In an early study by Hubbard and Send (16), tracking was investigated in regards to performance. The subjects were professional baseball players who visually tracked and then hit a baseball. It was discovered that tracking did not continue to the point of contact. At some point, peripheral clues were not necessary to make the appropriate striking response. Shope (25) in 1976 studied two striking

performances, one stationary and one moving and the relationship between various components. The results indicated no correlation between moving striking tasks and the perceptual components of visual acuity, coincidence-anticipation or dominance.

In an unpublished study by Williams (30), movement prediction ability and pursuit tracking was studied in children. The range in ages was five through twelve years of age. After seeing the initial projection of a ball, the children were asked to stand under an overhead platform where they could catch the ball if the platform was not overhead. This study enabled the investigators to measure reaction time and accuracy. It was concluded that younger children acted quickly with poor accuracy, while older children became more accurate and the oldest acted with speed and accuracy.

Summary

Investigators have determined that visual information processing is highly involved and is more complicated than just looking at an object. Studies have verified that man reacts to what he sees based on previous experiences and acts as a result of these experiences. The relationship of visual perception and motor skills is highly integrated. Many different studies have indicated a direct comparison between vision and performance. Color perception is a vastly complex series of not only light reflection upon the retina surface but a combination of many conditions including environment, emotions and

previous experiences. The limited research in regards to striking and perception leads this investigator to the necessity for further study in this area. It has been found that performance is influenced by a variety of factors such as ball color, background color, velocity, trajectory and differences in ages. To what degree all these variables play is a subject for further pursuit.

Chapter 3

METHODS AND PROCEDURES

This chapter describes in detail the methods and procedures that were used to collect the data needed to support or reject the hypotheses stated in Chapter 1. The main purpose of this study was to conduct an investigation on the affects of ball color and background color on the striking performance of elementary school children.

Sequence of the Experiment

The subjects participating in this study were boys and girls attending grades one, three and five in The Lenox School in New York City, New York. There were a total of ninety students, thirty per grade, in which the girls were randomly selected from the class population and all of the boys were included per grade.

Equipment

A Granada Pitching Machine, which was manufactured by Bruce Boys Manufacturing Company in Central Point, Oregon, was used for this study. The machine was designed to project plastic balls identified as "Fun Balls." These balls measured 2-15/16 inches in diameter, weighed 3/4 of an ounce, and had a skin thickness of .075 inch. The ball was designed with twenty-six holes to maintain a balanced flight in the air. This is commonly known as a whiffle ball pattern.

The balls were projected at a constant speed, having a flight

time of .7 seconds. The balls were projected thirty-two feet from the base of the pitching machine. The angle from the base to the support stand was one hundred degrees and was maintained throughout the study. Appendix A illustrates this situation. The projection box was fifty-five inches from the floor. The ball colors used in the study were red, blue, yellow and white and were supplied by the Cosom Company in Lakeville, Minnesota.

Two backgrounds were used in the study. One three yard by five yard white cotton drape was hung in the auditorium of The Lenox School. A black cotton drape of the same dimension was placed next to the white drape.

The machine was placed directly in front of the background approximately in the center of the drape for each subject. A distance of thirty-two feet was measured from the point of projection and marked by a taped line for reference.

The striking implement used was a wooden, paddleball racquet manufactured by Marcraft, Model #PT-30, measuring ten inches by eight inches with a seven inch combined throat and handle. The racquet was color coded for ease in recording performance. The coded racquet was used in conjunction with the striking scoring system. A diagonal, green strip covered the face of the racquet. The frame was outlined with a three-quarter inch red outline. The handle and throat were coded with alternating red and green diagonal stripes. Appendix B

illustrates the racquet.

A paddleball racquet was used to be consistent with the study which investigated striking performance by Moran (18). It was chosen because of the racquet's length, ease of handling and the ability of children to respond positively to the use of the racquet.

Scoring System

The scoring system used was the same system used in the Moran (18) study. It was a weighted four value system, ranging from zero to three. The scoring system, along with the color coded system, is presented in Table 1. The sytem was designed to evaluate the striking task in terms of performance. A simple hit or miss would not discriminate sufficiently in terms of striking performance. Previous studies by Moran (18) and Morris (19) which were concerned with either striking or catching used a graduated scoring system and it was found to be an acceptable determinant of performance.

Lighting

The illumination level of the testing environment was recorded prior to the testing proceedings. The auditorium of The Lenox School had no windows, therefore lighting was constant regardless of time of day or weather. A standard light meter was used to determine the illumination levels of the flourescent lighting, thirty-two feet from the projection machine. The illumination level for the flourescent

Table 1

SCORING SYSTEM FOR STRIKING

Points	Color Code	Type of Interception	Definition
3	Diagonal Green	Clean Hit	Contact made at face of racquet
2	Red Outline	Tipped Ball	Contact made at frame of racquet
1	Green and Red Diagonal Stripe	Handle Hit	Contact made at throat or handle of racquet
0	None	Miss	No contact made with racquet

was sixteen foot candles. The lighting was tested three times, spaced evenly throughout the testing period. Each time the readings were consistent.

Main Study

Subjects

There were ninety subjects participating in the study from the first, third and fifth grades of The Lenox School. The first grade group of thirty had an age range of six years and zero months to six years and eleven months. The third grade group of thirty had an age range of eight years and zero months to eight years and eleven months. The fifth grade group of thirty had an age range of ten years and zero months to ten years and eleven months. None of these subjects were used in the testor scoring accuracy testing.

Method

As the child entered, a score sheet was completed, stating the child's name, age, grade, sex, date and birthdate. The child was shown the projection box, paddleball racquet and the colored balls.

Instructions were then given in the following manner. The instructions were consistent for each subject.

> "You will be asked to attempt to hit thirty-six balls; six red practice, ten blue, ten yellow and ten white, using this paddleball racquet. You must keep the colored part of the racquet facing me. I want you to start at this line. Have your toes touch the line to start. You may move anywhere to strike the ball

once it leaves the machine. The balls will be picked up by you after we are finished."

After the child indicated that he or she understood what was expected, six red practice balls were projected. It was arbitrary which background was used first. When the child indicated he or she was ready, fifteen balls were projected for striking in the following manner: five blue, five yellow and five white. This order of ball color remained constant throughout each presentation. The balls were then picked up by the subject and replaced in the box while the machine was moved to the other background. The remaining fifteen balls were then projected in the same order as was previously presented. After the remaining balls were placed into the box, the child returned to his or her classroom. The entire testing procedure lasted approximately ten minutes.

Preliminary Testing

Before the actual testing of the subjects began, testing was conducted to establish the accuracy of the machine and the testor scoring. Pitching machine accuracy was established by projecting fifty balls toward an assistant who was standing at a predetermined spot, thirty-two feet away from the machine on a previously marked line. The assistant held the racquet at his side, waist high, while the balls were being projected. A deviation of six inches was determined acceptable. Forty-nine out of fifty projected balls fell within

the prescribed range. The procedure was duplicated two days later with a performance record of forty-eight out of fifty in the acceptable range. The accuracy of the two tests resulted in a ninety-seven percent score.

Testor scoring accuracy was established during the preliminary testing. Accuracy was established in the following manner: ten boys and girls from the fourth grade were asked to strike six red practice balls and then attempt to strike a total of thirty test balls, fifteen being projected from each background. As each subject reacted toward the projected ball, the testor and another professional physical educator scored the performance separately. This preliminary testing was done over three days, at one day intervals. A total of three hundred striking attempts were scored by each person. The score sheets were compared with a ninety-eight percent comparison of accuracy between the scorer and the testor.

Methods for Treatment of the Data

The design method used in this study was a repeated measures design for ball color and background color which was repeated for each subject. A four way analysis of variance with two repeated measures was used to test the hypotheses. A t test was used as a method of post hoc analysis for the significant main effects.

Chapter 4

PRESENTATION AND ANALYSIS OF DATA

Data for this study was obtained from elementary school children attending grades one, three and five in New York City, New York. Ninety students consisting of boys and girls participated in the testing during the months of April and May 1978.

A four-way analysis of variance with two repeated measures was the statistical procedure used to analyze the data. The order of presentation for this chapter will be as follows:

1. The four-way analysis was computed for the main effects of the independent variables of grade, sex, ball color and background color.
2. A discussion of the main affects follows the analysis.
3. Significant interactions concerning the main affects are itemized and discussed.
4. A summation of the data results are presented.
5. The hypothesis are restated with conclusions regarding the hypotheses being presented.
6. A discussion of findings concludes the chapter.

The computation of the four-way analysis of variance was completed at the computer center at Montana State University.

Analysis of Variance for the Main Effects

The standard deviations and mean scores for the main effects (grade, sex, ball color and background color) for all levels are illustrated in Table 2. A four dimensional factor design with only two repeated measures ball color and background color was computed using a four-way analysis of variance. The main effects had the following: grade had three levels, sex had two levels, color had three levels and background color had two levels.

In testing the first hypothesis, an ANOVA for striking scores produced F scores among ball color, grade, sex and grade and sex. The significance was set at the .01 level of confidence. The hypothesis that there was no significant difference among the color of the balls on the striking performance of first, third and fifth graders was rejected based on a significant F score for ball color. Table 3 presents the ANOVA for hypothesis one.

The ANOVA indicated that there was no significant difference among the grade, sex and grade and sex. A post hoc analysis to the analysis of variance for the main effect of ball color was applied using a t test. The general formula as outlined by Clarke and Clarke (4) was:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{SD_1^2 - SD_2^2}}$$

The level of confidence for the t-test was established at the .05

Table 2

MEAN SCORES AND STANDARD DEVIATIONS FOR STRIKING

Group	N	Blue		Yellow		White	
		Light Mean (S.D.)	Dark Mean (S.D.)	Light Mean (S.D.)	Dark Mean (S.D.)	Light Mean (S.D.)	Dark Mean (S.D.)
Grade 1							
Male	11	5.09 (3.21)	4.18 (3.97)	6.91 (4.23)	6.27 (3.13)	7.00 (3.61)	6.27 (3.04)
Female	19	2.26 (2.42)	2.26 (2.62)	4.21 (2.97)	3.84 (3.24)	4.32 (3.67)	3.68 (3.25)
Grade 3							
Male	10	8.00 (3.59)	8.00 (2.40)	8.90 (1.79)	9.50 (1.96)	9.60 (2.72)	9.80 (2.30)
Female	20	7.00 (3.16)	6.30 (3.34)	7.55 (3.46)	7.65 (3.63)	6.45 (3.33)	7.85 (3.07
Grade 5							
Male	12	9.67 (2.23)	9.83 (1.40)	10.58 (1.93)	10.83 (1.03)	10.42 (1.56)	9.92 (1.24)
Female	18	8.56 (2.71)	7.67 (3.25)	9.83 (2.23)	8.33 (3.33)	9.39 (2.43)	9.22 (2.46)

Table 3

ANOVA FOR BALL COLOR

Source	df	ms	F
Ball Color	2	28.71	5.00*
Grade	4	1.52	0.26
Sex	2	2.03	0.35
Grade and Sex	4	3.44	0.60
Residual (Error)	168	5.74	

*Significant at the .01 level of confidence.

level. Table 4 illustrates the t test used to identify the differences among the ball colors. Means and standard deviations were computed for each of the colors. Computing a t test between the mean striking scores using yellow and white balls proved that no significant difference existed. A comparison between yellow and blue balls was significant and a comparison between white and blue balls proved to be significant. The yellow balls produced the highest scores for striking performance, followed by the white balls and the blue balls producing the lowest performance scores.

Table 4

POST HOC ANALYSIS FOR BALL COLOR

Color	Mean	(S.D.)	Blue	Yellow	White	t test
Blue	6.33	(2.82)		7.61		2.556*
Yellow	7.61	(2.88)			7.54	.144
White	7.54	(2.82)	6.33			2.411*

*Significant at the .05 level of confidence.

In testing the second hypothesis, an ANOVA for striking scores produced F scores among background, grade, sex and grade and sex. Table 5 presents the ANOVA for hypothesis two. The hypothesis that there was no significant effect of the background color on the striking performance of first, third and fifth graders was rejected based on a significant F score for background color.

The ANOVA indicated that there was no significant difference among grade, sex, and grade and sex. The main effect of background color was significant and the white background produced higher striking scores than the black background.

In testing the third hypothesis, an ANOVA for striking scores produced F scores between sex and grade and sex. The hypothesis that there was no significant difference in the striking scores between boys and girls in the first, third and fifth grades was

Table 5

ANOVA FOR BACKGROUND COLOR

Source	df	ms	F
Background	1	70.67	13.93*
Grade	2	6.28	1.24
Sex	1	4.33	0.85
Grade and Sex	2	2.70	0.53
Residual (Error)	168	5.74	

*Significant at .01 level of confidence.

rejected, based on a significant F score for sex. Table 6 presents the ANOVA for hypothesis three. The main effect of sex was significant and the males had significantly higher striking scores than did the females.

Table 6

ANOVA FOR SEX

Source	df	ms	F
Sex	1	456.03	18.03*
Grade and Sex	2	14.20	0.57
Residual (Error)	84	24.92	

*Significant at .01 level of confidence.

In testing the fourth hypothesis, an ANOVA for striking scores produced F scores between grade and grade and sex. The hypothesis that there were no significant differences between the striking scores of first, third and fifth grades was rejected based on a significant F score for grade. Table 7 presents the ANOVA for hypothesis four.

Table 7

ANOVA FOR GRADE

Source	df	ms	F
Grade	2	1035.09	41.54*
Grade and Sex	2	14.20	0.57
Residual (Error)	84	24.92	

*Significant at the .01 level of confidence.

Since there were three grades tested, a t test was used to identify the differences among the three grades. Means and standard deviations were computed for each grade. Table 8 illustrates the t test; this table demonstrates that the striking performance of the first graders was significantly lower than the third and fifth graders. There is no significant difference between the third and fifth graders.

Table 8

POST HOC ANALYSIS FOR GRADE

Grade	Mean	(S.D.)	First	Third	Fifth	t-Test
First	4.69	(2.16)		8.05		-2.24*
Third	8.05	(2.96)			9.52	-0.77
Fifth	9.52	(2.26)	4.69			-2.53*

*Significant at .05 level of confidence.

Significant Interactions of Main Effects

The significant interactions was determined by the analysis of variance and only one was found to be significant; that was between ball color and background color. Table 9 presents the ANOVA for this interaction.

Table 9

ANOVA FOR INTERACTION OF BALL COLOR AND BACKGROUND COLOR

Source	df	ms	F
Background/Ball Color	2	31.44	6.19*
Grade	4	6.48	1.28
Sex	2	0.57	0.11
Grade and Sex	4	3.54	0.70
Residual (Error)	168	5.07	

*Significant at .01 level of confidence.