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The Influence of Color on the Teaching of Juggling to Elementary School Children

Anne C. McCoy
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THE INFLUENCE OF COLOR ON THE TEACHING OF JUGGLING
TO ELEMENTARY SCHOOL CHILDREN

By
Anne C. McCoy

A Thesis Submitted to the Faculty of Old Dominion University in Partial Fulfillment of
the Requirement for the Degree of
MASTER OF SCIENCE IN EDUCATION
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OLD DOMINION UNIVERSITY
AUGUST 2007

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ABSTRACT

The Influence of Color on the Teaching of Juggling to Elementary School Children

Anne C. McCoy
Old Dominion University, 2007
Dr. Linda M. Gagen, Director

Learning to juggle is difficult for elementary school students; it involves eye-hand coordination and complex movement patterns. Recognizing and using color for figure-and-ground visual perception is a necessary skill for tracking moving objects to catch them effectively. Can juggling instruction be influenced by the color of the juggling object used? Is one color more effective than another or does a combination of three different colors provide the most effective equipment choice?

Children in third, fourth, and fifth grade physical education classes were randomly assigned to color choices for juggling objects in a month-long unit of juggling instruction. The choices, all white, all brown, all blue, and a combination of white, brown, and blue, were used by each designated class consistently for the instruction, practice, and assessment lessons. Other variables included age, grade, and gender of the children.

Each juggling lesson lasted between 10-12 minutes and instruction given was identical regardless of object color. The final assessment of juggling was done by counting the total number of consecutive catches achieved over three trials. No significant differences were noted due to grade or gender. Significant color differences were noted, with all white having the lowest mean for total catches, which was significantly different from the other three color choices. The means for mixed colors...
and all brown were slightly less than the mean for all although those differences were not statistically significant. Since the upper portions of the gymnasium walls are white, it was concluded that those objects that did not blend with the wall color were more effective in allowing consecutive catching.
ACKNOWLEDGEMENTS

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# TABLE OF CONTENTS

LIST OF TABLES .............................................................................................................. viii

LIST OF FIGURES ............................................................................................................... ix

Chapter

I. INTRODUCTION ................................................................................................. 1
   STATEMENT OF THE PROBLEM ............................................................... 1
   STATEMENT OF THE PURPOSE ............................................................. 3
   SIGNIFICANCE OF THE STUDY ............................................................ 3
   RESEARCH QUESTIONS ........................................................................... 4
   VARIABLES ................................................................................................. 4
   HYPOTHESIS ............................................................................................... 5
   OPERATIONAL DEFINITIONS ................................................................. 5
   LIMITATIONS ............................................................................................... 6
   DELIMITATIONS .......................................................................................... 7

II. LITERATURE REVIEW INTRODUCTION ................................................... 8
   THE SKILL OF CATCHING ........................................................................ 8
   SPECIAL NEEDS CHILDREN AND THEIR ABILITY TO COMPLETE MOTOR SKILLS ........................................................................................... 9
   COACH/TEACHER MODELING ............................................................ 10
   ROLE OF VISION ....................................................................................... 11
   EFFECTS OF BACKGROUND COLOR, EQUIPMENT COLOR AND EQUIPMENT SIZE .................................................................................................. 13
   LIMB POSITION ......................................................................................... 15
   CONCLUSION ............................................................................................ 16

III. METHODOLOGY ............................................................................................ 19
   RESEARCH DESIGN ................................................................................. 19
   SAMPLE ....................................................................................................... 19
   INSTRUMENTATION ............................................................................... 20
   PROCEDURES ........................................................................................... 20
   DATA ANALYSIS ...................................................................................... 23

IV. RESULTS AND DISCUSSION ......................................................................... 24
   DATA ANALYSIS ...................................................................................... 24
   DESCRIPTIVE STATISTICS .................................................................... 24
   DISCUSSION ............................................................................................. 31

V. CONCLUSION .................................................................................................... 36
REFERENCES ................................................................. 39

APPENDIXES ............................................................... 42
  A. VERBAL CUES ....................................................... 42
  B. TASK CARD ......................................................... 43
  C. HISTOGRAMS ...................................................... 44

VITA ............................................................................ 45
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Descriptive Statistics</td>
<td>25</td>
</tr>
<tr>
<td>2. N by Groups</td>
<td>26</td>
</tr>
<tr>
<td>3. Group Mean by Grade</td>
<td>27</td>
</tr>
<tr>
<td>4. Group Mean by Gender</td>
<td>28</td>
</tr>
<tr>
<td>5. Mean Catches by Treatment</td>
<td>29</td>
</tr>
<tr>
<td>6. Tests of Between Subjects-Subjects Effects</td>
<td>30</td>
</tr>
<tr>
<td>7. Gender/Treatment</td>
<td>31</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cascade Ball Juggling</td>
<td>5</td>
</tr>
<tr>
<td>2. Cascade Scarf Juggling</td>
<td>6</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

Juggling is a skill that involves eye-hand coordination, dexterity, and showmanship. While learning to juggle, the students are unknowingly learning many physical education skills that involve visual and kinesthetic perception and manipulation (Van Donkelaar, Siu, & Walterschied, 2004). In this study, they found that eye movement begins prior to hand movement in skills that involve regular eye-hand coordination. Therefore, perception of the moving object is necessary before hand movement can be adjusted to catch it.

Observing a single-colored complex crossing pattern is an extremely difficult visual perception task for elementary school students. This may be due to the visual perception element of field-and-ground blending if the color of the juggling object blends with the background of the environment (Haywood & Getchell, 2005). By using multiple colors (three objects in a juggling cascade, with one object each of three different colors), students may be able to recognize and visually follow a more distinct pattern of the cascade; therefore, they may master the skill more quickly.

Statement of the Problem

Learning to juggle is difficult for elementary school students; it involves an advance rate of eye-hand coordination. Objects that move quickly through space provide more difficult challenges requiring quicker reaction times. Eye-hand coordination is an especially difficult skill for those with learning disabilities (Jongmans, Smits-Engelsman, & Schoemaker, 2003). With this in mind, students with disabilities may find the skill of juggling even more difficult than typically developing students. To accommodate this
lack of experience and any possible disabilities which may interfere with a students’
capability to learn juggling, the task must be adapted to make the task simpler.

Juggling with balls is a difficult task that increases the probability of spending
most of the instructional time chasing the balls instead of concentrating on the patterning
and manipulative requirements of the skill since balls move through space quickly and
require more mature reaction time ability and a higher level of skill development.
Juggling with plastic sheeting scarves decreases student distractibility because the plastic
sheets float more slowly in the air and remain stationary when they land. Using scarves is
a common methodology for physical education teachers to simplify the learning
experience in juggling for elementary school students (Pangrazi, 2007).

While the object choice is more obvious, the choice of color can be more difficult.
There is not a wide range of colors available in juggling scarves. Commercial scarves
come in sets of three colors, with one yellow, one blue, and one red included in each. No
color variation is suggested or offered (Sportime, 2006).

Scarf-like sheets cut from commercially available plastic bags provide a low cost
substitute object for elementary schools who cannot afford expensive, commercially
available products in large enough quantities for the students to have maximal activity
time. These bags come in blue, brown, and white. The typical configuration suggested
by commercial materials is for each child to use one sheet of each color. Is this the most
effective configuration for juggling instruction? Can juggling instruction be made more
effective based by varying the color of the juggling object used? Is one color more
effective than another or does a combination of three different colors provide the most
effective equipment choice?
**Statement of the Purpose**

The purpose of this study is to investigate whether the color of juggling objects has an effect on the ability of elementary school students to learn the task of cascade juggling.

**Significance of the Study**

This research will provide information regarding the influence of color on catching skills, specifically whether varying the color of juggling objects will affect the ability of children to learn this complex, novel skill. Juggling is a skill that requires specific catching skills, and therefore also requires visual tracking. Morris (1976) tested the effects of ball and background color in relation to the act of catching by elementary school students. He found that ball color alone, and in contrast to the background color of the environment did influence the catching scores of these elementary school children. Knudson and Kluka (1997) found that discernment of color affects visual perspicacity. Some individuals have difficulty choosing between red and green, or blue and yellow. Eight percent to ten percent of males and less than one percent of females have this color disability.

There is little research that suggests that juggling is influenced by color choice but juggling requires the use of visual discrimination to track a moving object within a background field to catch that object. The instructional material available for juggling is based on anecdotal evidence from the field but is not supported by research. This study will examine those anecdotal, unsupported opinions by testing the effects of color on this physical and perceptual task.
Dynamical systems theory in motor development examines the interaction of the abilities of the person during a movement task with the choice of equipment and the goals of the task and how those abilities will perform that task within the given environment (Newell, 1984). This theory would propose that the color of a juggling object interacting with (against) the background color of the gymnasium walls may either enhance or inhibit a child’s ability to visually track the object for catching (Gagen & Getchell, 2004). This study will examine the effects of the dynamical interaction of object color with the environmental constraints of wall color and general lighting and the individual constraints of visual perception and hand-eye coordination during a task of juggling for elementary school children.

Research Questions

Will varying the color of juggling objects enhance the ability of elementary school children to learn the skill of juggling? Does the use of three differently colored objects enhance the ability to juggle more effectively than using a single-colored set?

Variables

The independent variables for these analyses include object color, specifically the four treatment conditions with three using only single-colored bags (white, blue, or brown) and one condition using a combination of the three colors. Gender and grade levels (third, fourth, and fifth grade classes) are also independent variables. The dependent variable is the total number of successful consecutive catches a child can demonstrate during a summative assessment over three trials.
Hypothesis

**H_{A1}:** There will be a significant difference due to object color in the ability of elementary school students to make multiple catches in a juggling task.

**H_{O1}:** There will be no difference due to color in elementary school students ability to make multiple catches in a juggling task.

**H_{A2}:** Using a series of three objects that are differently colored will allow more successful catching than using all one color objects.

**H_{O2}:** There will be no difference between differently colored objects and one color objects in the ability to catch successfully.

Operational Definitions

A three-object cascade pattern will be used in this juggling study. A cascade pattern is when the objects being juggled are crossed in the air with each plastic sheeting piece thrown by one hand and caught by the other hand on each consecutive attempt (see Figure 1).

**Figure 1: Cascade Ball Juggling**

![Cascade Ball Juggling](http://wrwxv.pandas.currantbun.com/Jusslins/Juss.htm)

The difference in this cascade pattern between using juggling balls and bags is in the configuration of the hand when the objects are caught. Juggling balls are caught with the palms of the hand facing up and juggling plastic sheeting is caught with the hands facing down in a scratching movement (see Figure 2).

*Figure 2: Cascade Scarf Juggling*

![Cascade Scarf Juggling](http://www.skylight-circus-arts.org.uk/tpack/scarf%20juggling.html)

Students with special needs in this study will be defined as students assigned to this elementary school from a district-wide program including students diagnosed with the disabilities of emotionally disturbance (ED), learning disabilities (LD), and autism.

**Limitations**

One limitation of this study is the choice of the juggling object. Many people learn to juggle with balls, hoops, or beanbags. There are some compelling reasons to choose the slower-flying plastic sheeting for a sample of younger, more inexperienced jugglers but it is possible that this choice of object will not generalize to other juggling
objects. Color could be a critical characteristic in plastic sheeting but not in balls, hoops, or beanbags.

Another limitation is that this is a repetitive and invariant task, and long periods of practice on it may become boring for some learners, affecting their ability to attend to the task. Students may not be able to attend to practice for long enough periods of time to demonstrate a significant difference because of short attentions spans which would cause them to become mentally or physically fatigued by such repetitive movements.

A third limitation is the nature of the sample. The students in this study were selected from one single community school and diversity is not well represented in this population. These particular students may not behave in a way that will predict the motor behavior of the general population.

Delimitations

This study was limited to third, fourth, and fifth graders from one rural elementary school in the southeastern, coastal area of the United States of America. These children ranged in age from eight to eleven. This study did not include other grade levels. The juggling objects were plastic bags, including only blue, white, and brown bags. Other colored bags and other juggling objects were not considered. The instructional and practice time was limited to all or part of four class periods, spread over the course of one month. Additional practice time with teacher supervision was not available to the students.
CHAPTER 2
LITERATURE REVIEW

Introduction

The skill of catching, the ability to track moving objects with the eyes, teacher modeling, and dynamical constraints are all necessary components in the teaching of the physical skill of juggling. The literature base of these components will be reviewed in this paper.

The Skill of Catching

Angelakopoulos, Davids, Bennett, Tsorbatzoudis, and Grouios (2005) looked at hand preferences and constraints in catching. The researchers pre-tested 48 children, and placed them in poor, intermediate, and good catching groups. Good catchers were defined as catching 66.8% – 100% of the balls during the pre-testing conditions. Intermediate catchers caught 33.4% – 66.7% of the balls in the pretest. Finally, the poor catchers were defined as those who caught less than 33.4%. During the pretest, children were asked to try and catch 30 tennis balls with their favorite hand while standing inside a box with their favorite hand held with the palm facing down and the hand by their thigh. The children were 11.5 meters away from a ball machine with a 15.5ms velocity. The results of the pretest placed six boys and ten girls in the good catching group, eight boys and eight girls in the intermediate catching group, and ten boys and six girls in the poor catching group. The researchers then changed the task to a sitting position and standing position for the two catching study trials. The good catchers were not affected by the constrained positions, but were clearly more successful with their dominant hand. The poor catchers had difficulty maintaining postural control while catching in a seated
or a standing position. The intermediate catchers improved while sitting and worsened while standing.

Davids, Bennett, Kingsbury, Jolley, and Brain (2000) used a ball machine to deliver standardized throws to twenty children in a catching task. The children, all ten years of age, were positioned to free the non-dominant hand and asked to catch as many balls as possible using only one hand from a seated and then a standing position. The machine was placed 5.4 meters from the children. The children used their dominant catching hand rather than the hand closest to the ball placement. The authors concluded that environment and posture led to changes in this movement behavior. This research suggests that perceptual skills and subsystems like posture affect children’s performance in one-handed catching.

Savelsbergh and Van der Kamp (2000) observed catching in eight male and eight female child participants, who were randomly assigned to groups. Each group contained four males and four females. One group did a catching activity starting in the dark and finishing in the light. The second group started in the light and finished in the dark. In the final results, the researcher found that catching can take place in the dark but timing is delayed. In this research project, the gymnasium has a dim lighting system and the lighting conditions may have affected the catching skills of the children.

**Special Needs Children and their Ability to Complete Motor Skills**

Jongmans, Smits-Engelsman, and Schoemaker (2003) collected data on 749 children varying in age from 4 to 13 years. Of the 749 children, 214 were children who had been referred to a doctor for suspected motor problems. Of the 214 children, 147 attended special needs programs. The researchers placed the children in groupings of no
DCD (Developmental Coordination Disorder) or LD (Learning Disabled), DCD only, LD only, and both DCD and LD. The researchers gave each child the Movement Assessment Battery for Children (MABC) test for motor functioning in fine and gross motor skills. The test categories were manual dexterity, ball skills, and balance. They found that children with LD, children with DCD, and the children with a combination of both disabilities did not score high on hand-eye coordination when required to react quickly such as would be expected in a task of juggling.

Coach/Teacher Modeling

According to Hodges and Franks (2002), pre-practice is an important component to the learning and mastery process for a new physical skill. During pre-practice, the learner is able to listen to verbal directions and then see visual demonstrations from more skilled participants or perhaps from the teacher/coach. Also, the learner can perform many repetitions of the task in a controlled practice situation and receive feedback from the teacher/coach. This article was a meta-analysis of other previously published studies. The importance of a coach or teacher during a practice session was supported as a significant element in an early learner’s ability to master the skill. Hodges and Franks (2002) found that feedback during instruction, demonstrations of the skill, allowing errors to occur, and composing instructions that relate directly to the desired action should all be used to increase the skill level of the learner.

Anderson, Magill, and Sekiya (2001) used Knowledge of Results (KR) feedback with a spring attached to a stylus on a target board. Forty right-handed adults ranging in age from eighteen to thirty-five years old were randomly placed in four groups, with the constraint that group sizes be equal in number and gender. The groups created had two
sessions of KR, one with no delay and one with a two-trial delay. They also had an appearance or nonappearance of the spring, stylus (intrinsic-feedback manipulation).

Participants in two of the groups performed the skill of taking a stylus, from 80mm away, complete a fluid movement on a target without the spring connected to the stylus and were given KR either immediately or after each trial (Delay-0) or after two trials (Delay-2). Those two groups were given visual feedback after each trial that showed them where their stylus started on the target. Two groups did not receive any verbal or visual feedback. The researchers found that knowledge of results feedback helped the learner place the stylus closer to the target on subsequent trials. They also found that delays in trials affected the learner from drawing on the target.

Bastian, Lang, and Morton (2001) gave directions that enhanced the motor task with directed feedback. They told their subjects they would need to bend their arm or keep it straight for catching. Giving equal instructions prior to a session allows for prethought or visualization on the coming task, a strong element of motor learning. Each lesson included instruction and demonstrations using only the bag color or a color combination that was the randomly assigned color for that class. Silverman, Subramaniam, and Woods (1998) found that appropriate feedback, which correlates with the skill level of the participant, plays an important role in the learning of skills.

The Role of Vision

Beek and Huys (2002) took five intermediate level and five expert jugglers and asked them to complete three-ball cascade juggling in a reversed pattern and a typical pattern at varying timed beats. The focus of this observation was to track the visual focus of the juggler though timing changes. They found that both the intermediate and the
expert juggler changed the method of visually tracking the ball movement between the reverse and typical cascade patterns. Therefore, the researchers concluded that tempo and pattern changes affect the tracking patterns of the juggler’s eyes in jugglers of different experience and skill levels, but not in beginning jugglers.

According to Knudson and Kluka (1997), vision training in sports is important to the success of the skill. Knudson and Kluka wrote about the tendency of the eyes to fixate on moving objects. They also found that there is a state of eye dominance that is active during the vision task. We have a dominant eye just as we have a dominant hand. Golfers align the ball to the hole on a green using their dominant eye. Aiming tasks such as archery and rifle shooting use the dominant eye to sight the intended target. In the case of moving objects during a skill such as juggling, the dominant eye will make perception more acute on one side of the body than the other. Since juggling is a bilateral skill, eye and hand dominance occurring on only one side of the body makes the practice of a bilateral skill more difficult on the non-dominant side. If eye and hand dominance are not both on the same side of the body, a juggler might experience some coordination difficulties adjusting to the difference.

Knudson and Kluka (1997) also found that visual acuity plays an important role in sports because it allows the learner to focus clearly on an object. Anticipation is a skill that a more proficient athlete will demonstrate because they can foresee where the object will go before it gets there. Visual acuity enhances the ability to judge the speed and direction of a moving object and anticipate the trajectory and landing area, important concepts in the skill of juggling.
Van Donkelaar, Siu, and Walterschied (2004) found that saccadic eye movements were influenced by simultaneous reaching movements. Saccadic eye movements are voluntary movements of the eye that affect in changes of fixation during visual search. The participants were four men and two women with a mean age of twenty-seven. Each person had corrected to normal vision. The participants were in a room with dim lighting. The participants were looking down through a semi-silvered mirror. Reaching was directed toward a virtual target. A WATSMART® system viewed the movement of the index finger of the reaching hand of each participant with an infrared light. The virtual target was placed and moved three different times every 500-1500ms. The WATSMART® was able to test eye-hand coordination, pointing movements, and saccadic eye movements. The researchers found that limb movement occurred after the saccadic eye movement; the suggestion is that the signal must be predictive. This means that the participant knew prior to the study that he/she would need to use complex eye hand movement responses. In other words, the participant was predicting how they would need to react.

**Effects of Equipment Choice on the Task of Catching**

Issacs (1980) analyzed forty-five girls and forty-five boys aged seven and eight catching a combination of colored and different sized playground balls. The students came from a middle class elementary school, and they were selected at random. All ninety students were tested prior to the study to assure normal color discrimination and static distance visual acuity. Each student was randomly assigned a treatment mixture of ball sizes, using a selection of balls of six, eight and a half, and ten inches. Each student also went through eight catching trials with three ball colors. The colors were red, blue,
and multicolored (two red stripes and 2 blue stripes). Three stations were used in this study. Station one was the Ishihara Test for Color Discrimination. Station two contained one of each color of eight and half inch playground balls. The students were asked to verbally state and touch the ball they would rather play with. The child’s voice was recorded. The playground balls were rotated each time a different child came into the station to keep from promoting location preferences. At station three, each child was given practice time with a green seven inch playground ball. Each student was scored on a five point system for each attempt. Five points were given for a clean catch in the hands. Four points were scored for juggling the ball during a catch, using both the hands and the body. Three points were assigned for juggling the ball, using the hands and the body but dropping the ball. Two points were issued for arm or body contact and then the ball was retained but the hands were not used to catch. One point was given for arm or body contact, using no hands, and dropping the ball. Finally, zero points were given for initial body contact but no attempt to catch the ball. The researcher found that the boys caught more effectively than the girls. There was also a significant difference between the ability of the children to catch ten inch ball and the six inch ball, with the six inch ball representing an easier task. This study found that ball color was not significant enough to be reported; however, this researcher believed that children caught the ball of their preferred color more times than other colors.

Morris (1976) used a five point catching scale for students from second, fourth, and sixth grade to test the effects of ball and background color in relation to the act of catching. Ninety students, fifteen boys and fifteen girls, from these three grade levels were used in this study. There were no tests given relating to sight prior to the study.
Each student was asked to catch five blue, five yellow, and five white plastic balls in front of first a white, then a black 3 yd. by 5 yd. cotton background. The plastic balls were thrown to each child by a pitching machine thirty two feet away. Each student entered the testing area individually and was given a color perception test. Then the child was thrown six red plastic balls from the pitching machine against a green background for practice. During the actual study phase each student attempted to catch fifteen plastic balls (five of each color) for one background and then the background was changed and the same fifteen balls were thrown again. A five point system was used to score the catching ability of each child. Morris found that there was a significant difference between second grade and sixth grade student and their catching performance but not between fourth and sixth. He also found that boys caught more plastic balls than girls regardless of age. The white balls were found to have the lowest catching scores and the yellow and blue had the highest catching numbers. As far as background color is concerned, the white plastic balls against the white background produced the poorest scores and the blue balls against the white background produced the best scores. Therefore, it was concluded that ball color and background color did influence the catching scores of these children.

**Limb Position**

In Bastian, Lang, and Morton (2001) seventeen right-handed adults (fourteen women and three men aged twenty three to sixty years old) participated in a catching study. Nine subjects participated in study one and eight participants in study two. Each adult was asked to catch a ball dropped from above. The balls were two different colors, latex, twelve centimeters in diameter, and soft. The weight of the ball caught depended
upon the participants’ size and weight. The three hundred and twenty gram or five
hundred and forty gram ball was used with smaller participants and the four hundred and
fifty gram or six hundred and eighty gram ball was used for larger participants. The
participants were shown prior to the study which color represented the heavier ball and
which represented the lighter ball. The subjects were also told they would be switching
arms. The subjects were allowed one to three practice catches with the lighter ball and
were given a catching window. In study one, inter-limb generalization was measured.
Each participant caught the ball using the right or left arm in a bent position. Study one
had two phases: baseline with eight to twelve trials of catching the light ball with one
hand (one) and then the opposite (two). The adaptation phase was eighteen to twenty two
trials of catching the heavy ball with arm two. The transfer phase had the participants
catch the heavy ball with arm one. In study two a test of intra-limb generalization was
used. The subjects were allowed to have a bent arm or a straight arm, but could only use
their right arm (hand) to catch. All three phases from study one were used in study two
as well. The results showed that everyone adapted to the different ball weights quickly.
Also, all participants performed best in the first trial of the transfer phase than they did on
the first trial of the adaptation phase. In conclusion, the researcher found that healthy
individuals demonstrate generalization of adaptation in catching tasks.

**Conclusion**

This literature relates to the skill of catching, children with special needs and their
motor skill development, coaching and teaching models, the role of vision in movement
activities, the effects of background color, equipment color, equipment size, and limb
positioning during motor learning.
Angelakopoulos et al. (2000) stressed how much easier it was for children to catch with the dominant hand. Savelsbergh and Van der Kamp (2000) found that optimal lighting enhances the ability to judge both speed and direction of moving objects.

Jongmans et al. (2003) demonstrated that children with special needs have demonstrated motor and learning delays. The effect of color may be masked by a developmental delay in motor skills.

Hodges and Franks (2002) found that pre-practice teacher demonstrations and time spent in practice lead to increased ability in skill development. Anderson et al. (2001) found that lack of knowledge results and delays in feedback during activity lead to poor results in skill acquisition. Beek and Huys (2002) concluded that tempo and pattern changes affect the tracking patterns of the juggler’s eyes in jugglers of different experience and skill levels.

Using slower moving objects will encourage the ability to track the moving objects. Knudson and Kluka (1997) stated that visual acuity also plays an important role in sports because it allows the learner to focus clearly on an object. Van Donkelaar et al. (2004) found that eye movement occurs prior to limb movement in reaching for an object, making tracking problems more critical in motor learning.

Isaacs (1980) found that ball color was not significant enough to be reported. However Morris (1976) found that there was a significant difference in the ability of children to catch differently colored balls. In this work, white plastic balls against the white background produced the poorest scores and the blue balls against the white background did the best.
There is no literature assessing the affect of color in juggling skills. Juggling skills are related to catching and visual tracking but differ because of the complexity of the movement. Since ball color in catching is related to motor learning capability, and in the more complex task of juggling, the ability to track these moving objects may be affected by color and the field-and-ground blending into the background. Research is needed to clarify whether color is a confounding factor in the learning of complex catching skills such as juggling.
CHAPTER 3

METHODOLOGY

This study was designed to test whether varied color objects relate to the teaching of juggling to elementary school children. It investigated the hypotheses that object color will affect a child’s ability to perform the task of cascade juggling and that three colors in a cascade will be more effective in learning the cascade pattern than three objects of only one color.

Research Design

The research design used was quasi-experimental. One class from each of the three grade levels (3-5) was randomly assigned to juggle with either, all white bags, all blue bags, all brown bags, or a set with one bag of each color. Each class was given the identical verbal, visual instruction and feedback over three lessons for all four treatment conditions. Each juggling lesson took place during the first ten minutes of each class period. Assessment took place during the fourth lesson. Students counted for a partner and recorded the three trials on a rubric. Every student was videotaped during the trials to provide a visual check of the recorded results.

Sample

This research study used a sample of convenience, consisting of one hundred girls and ninety seven boys of varied ages and ethnicities, and a wide range of experience and developmental levels. The students were in grades third, fourth, and fifth at a small elementary school in rural southeastern Virginia. Permission was granted by the University Instructional Review Board under exempt status. Parents were informed that the research would be conducted as a part of the regular physical education curriculum.
The school retains videotape permission from parents for educational use within the school. Parents were given the opportunity to opt out their children from videotaping if they chose.

**Instrumentation**

The juggling objects used in this study were white, brown, and blue grocery bags. Each bag had its handles cut off and the bags were cut into half, making two plastic sheets of approximately 12” x 12”. On the last juggling session, one area of the gymnasium was set up as a video area. During the videotaping, each student juggled in front of the camera from a predesignated spot on the floor of the gym. Students rotated into this station during the course of the class time. As each student arrived at the camera station, they completed three juggling trials in front of the camera, completing as many consecutive catches as possible. If the bag is dropped or missed, the trial is ended. Students assisted each other in recording the results for each trial and these results were checked against the videotape for accuracy. The camera being used in videotaping was a Hitatchi Ultravision DVD-R 240x and the DVD-R tapes being used are Sony 30 minute DVD-R mini DV tapes. The camera was placed on a tripod for maximal stability and focal range was adjusted to see the entire juggling movement for each child.

**Procedures**

The study phase of this project consisted of three teaching days and one practice/filming day. Children in third, fourth, and fifth grade physical education classes were randomly assigned to color choices for juggling objects. The choices, all white, all brown, all blue, and a combination of white, brown, and blue were used by each class.
consistently for the duration of the instruction, practice, and assessment lessons. Other variables included grade level, and gender of the children.

Each juggling lesson lasted between 10-12 minutes and the instruction given was identical regardless of object color. The final assessment of juggling was done by summing the total number of consecutive catches achieved over three trials.

The school system offers an opt-out option for any film/photo sessions. There were four students in the classes who could not participate in filming. Children who could not be filmed still received instruction in and practiced the juggling skills, but were given another activity to participate in while other students filmed their cascade skills. Each juggling lesson lasted between 10-12 minutes, which varied only because of student questions, additional demonstrations, and behavior management.

During each lesson, the students entered the gym, began their normal warm-up, practiced the previous juggling lesson, and then followed their customary instructional routine and demonstration of that day's additional instruction on the cascade pattern. Each lesson, except for day three, involved the students finishing the lesson using an imaginary bag so they would be ready for the lesson to come. For example, day one the students learned how to juggle with one bag/object. At the end of lesson one the students pretended they had a second bag/object. This allowed for the students to envision the next step in the cascade juggling pattern. Each lesson also discussed the importance of catching with the palm down, like a cat scratching. Teaching keys and organizational details were discussed, which included instruction on how to move between catches and how to coordinate the movements of the hands.
Instruction included practice with both the dominant and non-dominant hands individually and proceeded with a consistent progression of skills until all three bags were incorporated into the juggling process. This skill progression was identical for each of the grade levels and all of the color conditions (see Appendix 1 for teaching keys utilized in this instruction).

On the final day, designated for assessment, the students warmed up, practiced the cascade juggling skills previously taught and then completed the demographic information on a task card (see Appendix 1 for the task card utilized). The students were then divided into two groups. One group proceeded with the filming of the three trials contained in the final assessment. The other group participated in a variety of station activities that did not involve juggling practice. Upon completion of filming the first group, the children switched places and the second group completed the videotaping of the assessment. The children worked with self-chosen partners to record the number of catches in each trial and to assure that the trials were conducted correctly.

Each class of 3rd, 4th, or 5th graders participates in physical education once per week. There are four classes in each grade level. All of the classes/grade levels were taught juggling skills the same way using different colored bags. The lessons were taught over a three week period as a first ten minutes of class activity to prevent exhaustion and boredom from the skill being used three lessons in a row. Practice time was available to students during the course of class work while integrating other activities in a similar manner for all three grade levels. On the fourth week, the students were assessed through a video assessment. The assessments incorporated three trials and used the sum of the catches of the three trials.
Data Analysis

Descriptive statistics and Pearson product moment correlations were run for all variables to get an initial picture of the data. Inferential analysis included a three by four by two ANOVA using the General Linear Model to assess group differences and look for interactions between the independent variables. The dependent variable was the total number of catches (summed) over three trials. The factorial variables are three groups of grade levels, two groups of gender, and four groups of object color. For these data, histograms were run to examine the normality of the data. Tukey’s HSD post hoc test of differences was used to show where the group differences and interactions occurred for the multilevel variables of grade and color condition.
CHAPTER 4

RESULTS AND DISCUSSION

This study investigated the effect of color on the teaching of juggling to elementary school children. Single colored and varied colored combinations of juggling objects were used to assess the effect of color on the ability to perform sequential catching in a cascade pattern.

Data Analysis

This study looked at the influence of color on the teaching of juggling to elementary school children. Did varying the color of juggling objects enhance the ability of elementary school children to learn the skill of juggling? Did the use of three differently colored bags enhance the ability to juggle more effectively than using a single-colored set of three bags?

In the data set, there were six outliers that were removed from the analysis to avoid having the means affected by these severe scores. Three students were removed who each completed more than 75 catches higher than the next highest students. Three students with special needs who had total scores of zero for all three trials were also removed.

Descriptive Statistics

Data for 197 students in three grade levels was analyzed. The students in this study ranged in age from eight to thirteen years with the mean age of ten (see Table 1 for the appropriate descriptive statistics for each of the three trials and total catches).
Table 1:

Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Catch Trial 1</th>
<th>Catch Trial 2</th>
<th>Catch Trial 3</th>
<th>Catch Trial Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>3.60</td>
<td>4.06</td>
<td>4.08</td>
<td>11.74</td>
</tr>
<tr>
<td>Median</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>9.00</td>
</tr>
<tr>
<td>Mode</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>3.643</td>
<td>4.379</td>
<td>4.371</td>
<td>10.325</td>
</tr>
<tr>
<td>Range</td>
<td>21</td>
<td>35</td>
<td>29</td>
<td>58</td>
</tr>
<tr>
<td>Minimum</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>22</td>
<td>35</td>
<td>29</td>
<td>60</td>
</tr>
</tbody>
</table>

The N for the factor groupings (gender and grade level) was well distributed, showing all groups with a balanced number of participants. Gender was equally distributed with 100 and 97 boys. Each grade level had between 60 and 69 children. Therefore, severe group distributions were not a problem in these data (see Table 2 for N by group).
Table 2:

*N by Groups*

<table>
<thead>
<tr>
<th></th>
<th>N=199</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>97</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>42</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>53</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>54</td>
</tr>
</tbody>
</table>

While the data for the three trials of catches were very positively skewed, they were similarly skewed for each of the three trials, showing an effect for inexperienced students and not an unusual effect for any of the treatment conditions (see Appendix B for histograms of these data).

The independent variable of grade level showed no significant main effect ($F = 1.588, df = 2, 195, p = .207$). Group means were slightly different for each grade and showed an increase in total catch count for the higher grades over the lower grades. This is an expected result and follows known developmental trends for skills to become more mature with increased experience in related skills such as catching (see Table 3 for
group mean data by grade). However, this trend difference between grades was not statistically significant.

Table 3:

**Group Means by Grade**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=199</td>
<td>10.148</td>
<td>1.289</td>
</tr>
<tr>
<td>3</td>
<td>12.122</td>
<td>1.253</td>
</tr>
<tr>
<td>5</td>
<td>13.293</td>
<td>1.224</td>
</tr>
</tbody>
</table>

Dependent Variable: Total Catches

Gender showed no significant main effect \( (F = 0.202, \text{df} = 1, 196, p = .654) \) for total catches. The means are balanced between the two genders (see Table 4 for group mean data by gender). This is an expected finding since girls and boys are known to have similar skills throughout childhood until the onset of puberty (Haywood & Getchell, 2005). There were no significant interactions for grade by treatment \( (F = 1.993, \text{df} = 6, 191, p = .069) \) or gender by treatment \( (F = 0.391, \text{df} = 3, 194, p = .760) \).
Table 4:

*Group Mean Data by Gender*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>12.180</td>
<td>1.039</td>
</tr>
<tr>
<td>Female</td>
<td>11.529</td>
<td>1.011</td>
</tr>
</tbody>
</table>

*N* = 199 (100 Female/97 Male)

The first research hypothesis stated there would be a big difference in juggler’s performance due to color. There was a significant main effect for color in these data (*F* = 4.894, *df* = 3, 194, *p* = .003). The best performance was among the participants using the all blue bags. The mixed color bags were second and the brown bags were third (see Table 5 for group means). The means for the all blue, the mixed colors, and the all brown bags were not significantly different from each other. The all white bags were the lowest of the group means and were significantly different from all three other color treatments.
Table 5:

Mean Catches by Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=199</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>6.870</td>
<td>1.546</td>
</tr>
<tr>
<td>Blue</td>
<td>14.022</td>
<td>1.422</td>
</tr>
<tr>
<td>Brown</td>
<td>13.025</td>
<td>1.412</td>
</tr>
<tr>
<td>Mixed Colors</td>
<td>13.501</td>
<td>1.416</td>
</tr>
</tbody>
</table>

Dependent Variable: Total Catches

A subset of scores was selected to examine the catching scores of special needs students (N = 64) included in the physical education classes. A significant difference was found between the third and fifth grade students in this subset ($F = 2.240, df = 7, 56, p = .044$). Table 6 shows the mean differences between the special needs students by gender and treatment color.
Table 6:  

*Gender by Treatment for Special Needs Subset*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Gender</th>
<th>Treatment</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N=64</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>White</td>
<td>7.667</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Colors</td>
<td>14.000</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>White</td>
<td>3.750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Colors</td>
<td>9.000</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>White</td>
<td>7.200</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>White</td>
<td>6.286</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>Blue</td>
<td>22.700</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Blue</td>
<td>11.250</td>
</tr>
</tbody>
</table>

Special needs students also caught the color blue better than the other treatments used, consistent with the findings for this study. The catching difference between white and blue almost tripled (see Table 7 for composite mean catch totals by treatment). There is a strong but non-significant difference between the blue bags and the mixed bags for this population. Brown is not included as a treatment color choice in this subset since none of the groups of special needs students were assigned to a class using all brown as a treatment.
Table 7:

Mean Catch Totals by Treatment in Special Needs Subset

<table>
<thead>
<tr>
<th>Treatment Color</th>
<th>Mean Catch Total</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>6.226</td>
<td>2.373</td>
</tr>
<tr>
<td>Blue</td>
<td>16.975</td>
<td>2.924</td>
</tr>
<tr>
<td>Mixed</td>
<td>11.500</td>
<td>3.082</td>
</tr>
</tbody>
</table>

Discussion

The first hypothesis tested whether there was a significant difference due to object color in the ability of elementary school students to make multiple, sequential catches in a juggling task. There was a significant difference in object color, with blue, brown, and mixed colored objects significantly different than white objects in the ability for children to perform multiple, sequential catches in a juggling task.

Catching is a coincidence-anticipation skill. In order to catch effectively, children must be able to judge the movement of the bags and then decide where the bag will be to enable interception with the hand. Since the hand and the bag were both moving, this is a difficult task constraint. Developmentally, the judgment of movement is a more complex skill (Haywood & Getchell, 2005). In this case, the movement of the all white bags was somewhat screened by blending into the wall color and did not allow children the most effective judgment of the motion. Apparently, the blue and the brown bags contrast well with the wall color and provide optimal visibility to track the moving objects, allowing...
the mixed colors that contained one blue and one brown object to be a successful combination of equipment.

In this study, there was a significant main effect for treatment color. The blue, brown and mixed colored bags produced the best catching performance. Blue and brown can be seen easily in contrast to the two colors on the gym walls. It is interesting to note that blue was the color that Morris (1976) found to be most effective in catching against a white background. The blue bags being tossed in this study were visually tracked from the maroon section into the white section of the gym walls and consistently produced the highest mean catching scores among students from all grades and both genders, higher than the brown and mixed bags but not significantly different from them. Apparently, blue and brown are colors that provide optimal contrast with both dark and light backgrounds.

This was an unexpected result. It was predicted that the mixed color bags would be related to the best performance. The mixed color bags were not significantly different from the all blue or all brown bags and the all blue bags had the highest of the group means. The all white bags were significantly worse than the other colors. In looking back at the research from Morris (1976), he found that his worst results came from catching a white ball against a white background. This is not an unexpected result in this study since the walls of the gymnasium used in this research are white above chair rail level with a maroon color from chair rail level down to the floor. The white bags may not provide enough figure-and-ground contrast with the white walls in the dimly lit gymnasium to allow optimal visibility.
The second research hypothesis stated that use of three different colored bags would enhance the skill of juggling more effectively than using three bags of a single color. This hypothesis was rejected as the mixed colors did not differ significantly from the single colors of blue or brown. In this case, the mixed color bags had no more effectiveness than the single color brown or blue bags. While it was originally thought that the pattern of the cascade would be more discernible using three colors that alternate within the pattern, apparently this is not a determining element for children to achieve success in the skill of juggling. The treatment differences were consistent across all three grade levels. Blue, brown and mixed were caught significantly more than white in all three grade levels.

Knudson and Kluka (1997) found that visual acuity also plays an important role in sports because it allows the learner to focus clearly on an object. Anticipation is a skill that a more proficient athlete will demonstrate because they can foresee where the object will go before it gets there. Visual acuity enhances the ability to judge the speed and direction of a moving object and anticipate the trajectory and landing area. The hypothesis stated three colors would allow for students to focus on the three separate objects in a pattern, which would enhance the ability to catch the bags in the correct order, eliminating confusion about which bag should be caught.

There are a variety of students with special needs who participated in this study. In this study, students with special needs (N = 64) were studied as a pull-out sample. In the group of students with special needs, none were in the classes randomly assigned to the all brown bags. The blue bags and the mixed bags were significantly better than the white bags for these students, consistent with the typically-developing students in the
classes. In this case, the mean for the blue bags was much higher than in the typically-developing population and represented a score almost three times the mean for the white bags. Jongman et al. (2003) found that students with special needs have difficulty with reaction time, balance, and hand-eye coordination. In these data, the students with special needs performed consistently well with the typically-developing students but demonstrated greater mean differences between the color treatments, with all blue demonstrating a higher but non-significant difference with the mixed colors.

Learning to juggle is difficult for elementary school students; it involves eye-hand coordination at an advanced rate. Objects which move quickly through space provide more difficult challenges requiring quicker reaction times. Eye-hand coordination is an especially difficult skill for those with learning disabilities (Jongmans et al., 2003). Several participating students wear glasses and may have had difficulty tracking the bags. One student in this sample had a physical disability associated with limited arm movement and that would have prevented accurate tossing and reaching during this skill. Students classified as learning delayed (LD) exhibit processing problems, which can lead to inability to remember the tossing and catching order and sequence the catching movements.

It seems that the determining issue in learning to juggle is the visibility of the movement of the bags, rather than discerning the patterning of the catches. The necessary cross-handed catching movement was able to be accomplished whether or not the pattern was highlighted by the use of multiple colors. Pangrazi (2007) lists verbal and visual cues that can be used in the teaching of cascade juggling. Pangrazi does not mention color in his instruction he just lists cues. The importance is laid on catching
down (clawing), eyes on scarves, and using two hands. In cascade juggling the
importance is in the patterning. Therefore, based on these data, color is an important
factor in choosing juggling objects to teach the motor skill of juggling.
CHAPTER 5

CONCLUSION

This study demonstrated that varying the color of juggling objects enhanced the ability of elementary school children to learn the skill of juggling. The colored juggling sheets chosen for this study were white, blue, and brown. The facility used in the study has two toned walls. The bottom color is a dark maroon and the top color is white. The facility also has a dim lighting system raised very high above students' heads. Under poor lighting conditions, contrast of colors becomes more important in a child's ability to distinguish the movement of the juggling objects.

This is an important finding for teachers who are choosing equipment for catching tasks and are concerned about background and lighting in the gymnasium spaces for these activities. It is not known whether this would also be significantly different if the activity was moved outdoors into a field space with different colored environments.

Plastic bags were used rather than juggling scarves because of budgeting concerns. Plastic bags provided a satisfactory alternative and were available in multiple colors sufficient numbers to allow effective moderation of the desired skill and optimal activity among students. Catching a bag/scarf allows for the object to float, allowing for more catching time as opposed to a ball that drops quickly once thrown and rolls away if not caught. Selecting equipment effectively is one of the precepts of the dynamical systems theory. It is important for teachers to pay attention to choosing equipment that best enhances a child's ability to learn a physical skill and perform it successfully (Gagen & Getchell, 2005). In this case, the choice of equipment allowed for maximal practice.
time and ease of manipulation of the objects so that students could concentrate on the pattern of the cascade.

The students in this school have organized physical education once a week for forty minutes. When these classes are missed due to assemblies, field trips, and a variety of other school activities, it lengthens the time between juggling lessons. While the timing of the instruction did not produce a significant difference, extended times between classes may have played a part in why some of the juggling scores were lower than expected. Without intermediate guided practice sessions, the students may not remember how to complete the skill from week to week. Light et al (2000) ran a year long experiment of daily physical education and once a week physical education. They used a written and physical activity battery of post tests. The daily physical educated students out scored the once a week children in both categories proving that continual close together practice of skills and knowledge leads to more information and skill retention.

In conclusion, the results were not completely expected. In the future, three bag colors that contrast with the gymnasium walls might be more effective. Blue, brown and mixed were effective color choices based on the data from this study. In future lessons, it might be reasonable to examine the effectiveness of yellow objects since yellow is known to be a visible color against many backgrounds. It would be interesting to see if the blue, yellow, and brown would work well together in the cascade juggling pattern.

Having a brightly lit room would be more effective in enhancing tracking of moving objects. Important data was learned from the color treatments. This treatment of blue, brown, and mixed objects proved to be easier to catch for all three grade levels and both gender groups. These colors provided a contrast to the two toned gym walls and
were easy to track in the dimly lit gym. White objects should not be used in future instruction because of the lack of contrast to the wall colors. Future instruction will be more effective utilizing the color information from these data.
REFERENCES


APPENDIX A

Verbal Cues

The following is a list of verbal cues taught to the children each lesson day regardless of color variance:

1. Lesson One: Toss–Toss–Catch (R – L – L –)
3. Lesson Three: Toss–Toss-Catch-Toss-Catch (R-L-L-R-R)
   a. Completing the pattern with: Toss-Catch-Toss-Catch (L-R-L-R)
4. Filming Day: Review/practice complete pattern Toss-Toss-Catch-Toss-Catch-
   Toss, etc… (R-L-L-R-L-L-R-L-R-L-R-R, etc…)
APPENDIX B

Task Card

Cascade Juggling Task Card

<table>
<thead>
<tr>
<th>Juggling Task Card</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Student Juggling: ____________________________</td>
</tr>
<tr>
<td>Birth Date of Student Juggling: ______________________</td>
</tr>
<tr>
<td>Trial #1 (How Many Catches?): ________________________</td>
</tr>
<tr>
<td>Trial #2 (How Many Catches?): ________________________</td>
</tr>
<tr>
<td>Trial #3 (How Many Catches?): ________________________</td>
</tr>
<tr>
<td>(T)________________</td>
</tr>
<tr>
<td>(Teacher Will Fill This In)</td>
</tr>
</tbody>
</table>
APPENDIX C
Histories

Histogram 1: Catches in Trial 1

Histogram 2: Catches in Trial 2

Histogram 3: Catches in Trial 3

Histogram 4: Total Catches

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VITA

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I am currently a full time K-5 Health and Physical Education teacher, a 2nd-5th grade Computer Resource, and 1st grade Reading Enhancement teacher at Oakland Elementary School in Suffolk, Virginia. I am also the Web Master and the creator of Learning Links which maintains curriculum and SOL help for students and teachers at Oakland. I lead Oakland’s Resource Team which develops monthly activities that teach the academic SOL’s through Physical Education, Music, Art, and Media. I also sponsor a Golf Club that meets once a month during school hours and provides our students with the opportunity to display their skills on an actual golf course at the end of each school year. I am also the percussion director for the Oakland Band, the only elementary band in the city of Suffolk. Professionally, I am an advocate for Physical Education and served as the Virginia Association for Health, Physical Education, Recreation and Dance Elementary Physical Education Chair in 2004.