1-1-2006

Colored overlays and symbol identification in pre-school children with disabilities

Edith A Naas
University of Nevada, Las Vegas

COLORED OVERLAYS AND SYMBOL IDENTIFICATION IN PRE-SCHOOL CHILDREN WITH DISABILITIES

By

Edith A. Naas

Bachelor of Science
Columbia University
1962

Master of Arts
Columbia University
1994

Master of Education
Columbia University
1998

A dissertation submitted in partial fulfillment
of the requirements for the

Doctor of Education Degree in Special Education
Department of Special Education
College of Education

Graduate College
University of Nevada, Las Vegas
May 2006

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Dissertation Approval
The Graduate College
University of Nevada, Las Vegas

April 10, 2006

The Dissertation prepared by

EDITH NAAS

Entitled

Colored Overlays and Symbol Identification in
Pre-School Children with Disabilities

is approved in partial fulfillment of the requirements for the degree of

Doctor of Education

Examination Committee Chair

Dean of the Graduate College

Examination Committee Member

Examination Committee Member

Graduate College Faculty Representative

1017-52

ABSTRACT

Colored Overlays and Symbol Identification in Pre-School Children with Disabilities

by

Edith A. Naas

Dr. John Filler, Examination Committee Chair
Professor of Special Education
University of Nevada, Las Vegas

The purpose of this study was to determine if pre-school children, with and without disabilities, could identify symbols more accurately while looking at the symbols through colored overlays.

The LEA Playing Cards and the LEA Near Vision Test were used to assess the ability to point to a symbol. To screen for the preferred color overlay the Cerium Colour Overlays were used.

Eighteen children, aged 3 to 5 years participated. Nine were children with disabilities, nine were children without disabilities.

A screening determined if each child could match four common symbols by pointing. Three groups were formed. Each group included three children with disabilities and three children without disabilities.

A Pretest involved having each child point to four symbols on the LEA Near Vision Test first with the Test card was covered with a clear overlay, second with the preferred color overlay and, finally, with a randomly chosen non-preferred color overlay. The Intervention procedure was the same as the Pretest procedure with the exception that each group used a different type of overlay. Group I used a clear overlay, Group II used the preferred color overlay, and Group III used the randomly chosen, non-preferred color overlay.

The analyses included a one-way ANOVA with repeated measures between the Pretest scores and the Intervention scores, a one-way ANOVA comparing the Intervention scores between those with and without disabilities, a one-way ANOVA comparing the Intervention scores between the three groups, a two-way ANOVA comparing the interaction between the Intervention scores of the group factor and the disability factor, and a two-way ANOVA comparing the preferred color choices between the disability and overlay conditions.

The results showed no statistically significant differences between the Pretest and Intervention accuracy scores. The results of the one-way ANOVA with repeated measures between the Pretest scores and Intervention scores did approach statistical significance of $p = .089$. Interaction between the group and disability factors were not statistically significant. There was a trend in which the children with disabilities achieved higher Intervention mean scores when using colored overlays. No single color dominated preference.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I am deeply indebted to the members of my Dissertation Committee at the University of Nevada, Las Vegas, Dr. John Filler, Dr. Nancy Sileo, Dr. Jeffrey Gelfer and Dr. W. Paul Jones, for their encouragement, patience and advice during the process of completing this study. My special thanks to Dr. John Filler, who agreed to be Chairman of this Committee, and whose sage and sometimes impassioned guidance kept me on task. Also, many thanks to Dr. W. Paul Jones, master statistician, who helped greatly in clarifying the analysis of the results of this study. I am indebted, also, to Dr. Arnold Wilkins at University of Essex, United Kingdom, for generously sharing his time and expertise.

This study would not have been possible without the participation of the children, parents, teachers and teacher's aides at the Lynn Bennett Early Childhood Education Center. I greatly appreciate the help from Dr. Catherine Lyons, past Director of the Center, and from Mardene Wright, present Director of the Center, who graciously shared their time and knowledge about the practical aspects of working with pre-school aged children. To the dedicated teachers and teacher's aides at the Center, I am indebted for taking time out of their busy schedules to escort children to the testing area and for their encouragement. Finally, to the parents who allowed their children to participate in this study, and to the children themselves, who taught me a lot – many thanks.

CHAPTER 1

INTRODUCTION

History

Since the mid 1800s researchers have studied the effects of color on human behavior. For example, Babbitt (1878) claimed to have cured many ailing individuals by having them sit in a cabinet where they could be surrounded by various colored lights. Spearman in 1904 investigated differences on intelligence tests in normal individuals when different colored filters were used to change the lighting, while Goldstein in 1942 studied how color impacted on the physical abilities in those with motor impairments.

These early studies have been criticized as being anecdotal and using poor experimentation (Kaiser, 1984). Despite this criticism, the belief that color has an impact on mental and physical states remains strong. Color coordination continues to be studied in educational settings and by designers of factories and hospitals (Varley, 1980, NBS Special Publication 516).

The effects of color are not the same for everyone. Studies on individual preference for a particular color have shown that there is considerable variability among adults and children. In a study of color preference versus form preference in 145 three to six year olds, Suchman and Trabasso (1966) showed that younger children most often chose objects if they were of a color that the child preferred. In contrast, older children most often made choices according to the form of the object.

Since the younger children tended to choose objects according to their preferred color, the authors suggested that color preference could be utilized to help children who are experiencing delays in their development. It also was suggested that attention could be facilitated or interfered with depending upon whether the objects to be focused upon were of the preferred or non-preferred color.

The use of color as a curative for disease is generally not accepted. However, those studying ophthalmology, and in some areas of education, color is used to help improve visual function. For example, covering text material with tinted plastic sheets of various colors has been used with children with reading delays (Irlen, 1983). In addition, it has been shown that colored overlays mediate visual processing by decreasing symptoms that make it difficult to focus among children with reading delays (Babcock & Lovegrove, 1981), dyslexia (Stanley, 1987) and specific learning delays (Evans & Drasdo, 1991).

Colored overlays when placed over text has been shown to diminish visual distortions such as letters appearing to move on the page, blurring of vision (Irlen, 1983) or eye strain and headache (Wilkins, et al., 1991). These visual distortions were not detected with routine optical examinations of visual acuity, but nevertheless, led to reading delays even though the subjects were of normal intelligence and had no other physical disabilities.

The literature review will describe research indicating that these types of visual symptoms may occur when there is an impairment of the cortical visual system of the brain, specifically the transient visual system. It is believed that this impairment results from a problem in the visual cortex rather than a deficit of the eye itself. In addition, the research suggests that covering text with different colored overlays may alleviate these visual symptoms (Breitmeyer, 1978). No studies have been found that attempt to determine if pre-school children with disabilities show signs of transient visual system deficit (TVSD).

Children with disabilities other than reading delays also show these same visual symptoms. Bodis-Wollner (1972) studied teenagers and young adults with cerebral lesions who had normal visual acuity but continued to have difficulty with reading because of blurred vision. Teens and young adults with mental retardation and Down syndrome improved their reading skills when different colors were used to contrast backgrounds from black text (Grewal, Haward & Davies, 1987; Huang & Borter, 1987). In addition, those with brain damage have been shown to respond differently to background colors from those with mental retardation (Goldstein & Oakley, 1986; Grewal, Haward,& Davies, 1987).

An early study by Strauss (1941) also demonstrated differing responses to color among children with disabilities. Three groups of children aged 7 to 10 years were compared. The groups included children without disabilities, children with mental retardation and children with brain damage. The participants were shown nine cards with black line drawings on two types of backgrounds. One background was plain white. The other background type was more complex and consisted of backgrounds of wavy or jagged lines and squares or crosses. The drawings to be identified were of common objects such as a hat or a teacup. The task was to distinguish the objects that were either on a plain white background or embedded in the more complex backgrounds.

The results showed that there was only a slight difference between the performance of the children without disabilities and those with mental retardation in distinguishing figures embedded in complex backgrounds. However, the children with brain damage responded more to the complex backgrounds rather than the figures, and failed to discriminate between the figures and the backgrounds. When the complex background was changed to blue, the ability of the children with brain damage to distinguish the figures improved. The authors suggested that a change in the color combination reduced the background interference enabling improved performance among the children with brain damage.

To date, no research has been found that investigates the impact of color on preschool children with disabilities. Some studies occurring in mainstream classroom have included children with mental retardation, cerebral lesions and Down syndrome. Unfortunately, the specific numbers and distributions of children with each of these disabilities were not reported.

An important event impacting upon education has been the increased use of computers in schools and at home. Even children of pre-school age are able to play games and learn skills such as matching letters and symbols on computers (Haugland, 1992). With the increased use of computers in early childhood classrooms, it is important to be able to read and identify symbols in text as well as read and identify symbols on a computer screen.

Research investigating the visual symptoms previously described (letters appearing to move on the page and blurring of vision) when subjects viewed computer monitors has been performed under two different conditions. One condition demonstrated that a change in the background color of the monitor or a change in the intensity level of the background color helped to clarify the symbols on the monitor. This was believed to have led to improved reading abilities (Croyl, 1998). The second condition involved covering the computer monitor with overlays of the preferred color or with frosted acetate overlays (Saint-John & White, 1988). In this study, frosted acetate overlays generally caused mild blurring of vision. However, in some cases of those with TVSD, using the frosted acetate overlays actually improved vision when looking at the computer monitor. The results also showed that the colored overlays placed over computer monitors resulted in similar changes as those occurring when the overlays were placed over regular text. Once again, no studies have been found that involve color and computer monitors in pre-school aged children with disabilities.

Although the research concerning the improvement of computer skills and the incidence of transient visual system deficits (TVSD) in pre-school children with disabilities are important ones, they will not be addressed in this study.

Purpose of the Study

The first purpose of this study is to determine if there is a statistically significant difference between Pretest scores and Intervention scores in the accurate identification of target symbols for each child within three groups. One group will be asked to identify symbols on a card that will be covered with a clear overlay. A second group will be asked to identify symbols on a card covered with the preferred color overlay and a third group will be asked to identify symbols on a card covered with a non-preferred, randomly chosen color overlay.

The second purpose of this study is to determine if there is a statistically significant difference between Pretest scores and Intervention scores in the accurate identification of target symbols between children with and without disabilities.

The third purpose of this study is to find the preferred color for each child and to determine if there is a color that dominates preference.

Null Hypotheses

Based on the areas of investigation in this study the null hypotheses are:

1) There will be no statistically significant difference between the Pretest accuracy scores and the Intervention accuracy scores among the children using a clear overlay, the preferred color overlay or the non-preferred randomly chosen overlay.

2) There will be no statistically significant difference between the Pretest accuracy scores and the Intervention accuracy scores of children with

disabilities and those of children without disabilities for the conditions of clear overlay, preferred color overlay or randomly chosen, non-preferred color overlay.

3) There will be no color that dominates preference.

Significance of the Study

Of the children entering early intervention programs in 1999-2000, approximately 8% were diagnosed with visual impairments that were obtained by standard optical examinations (DOE, 2001). Forty percent of those with reading delays, of primary school age, whose visual acuity was normalized with the use of eyeglasses continued to show symptoms such as blurring of text and letters appearing to move on the page (Evans, et al., 1999). Considering the importance of the ability to read and perform reading related tasks in education, it is essential to facilitate such tasks in children as early as possible (Jones, 1998). The sooner that children are provided with programming that addresses the causes of learning delays and reading delays, the more likely it is that they will require fewer services later in life (DOE, 2001). Even with considerable research regarding the possible causes and treatments of reading delays, large numbers of students continue to read below their grade level, despite attempts at remediation (Robinson & Miles, 1987).

Much of the research involving children with reading delays has included those without disabilities and who are of average intelligence. Some studies have taken place in mainstream classrooms that included children both with and without disabilities (Wilkins, et al., 1992).

With increasing numbers of children with disabilities being placed in regular classrooms (IDEA, 1990), it is important to identify strategies that will enable these children to improve their academic skills. However, the solutions must be feasible for use in the classroom. Placing colored overlays over text material to help sharpen focus on words or symbols can be done easily without time-consuming preparation by teaching staff.

Studies will be presented in the literature review of children with reading delays who have been diagnosed with a deficit of the visual cortex and who have improved in speed and comprehension of reading when colored overlays were placed over text material. Additional research on how changing the background colors and intensity levels of computer monitors improved the capability of seeing the screen clearly will be reviewed. As previously stated, neither the research investigating color and computers or the incidence of TVSD will be addressed in this study.

Most studies include children over the age of six years. Very often the subjects differ in age range by as much as 5 years. It is difficult to assess the effects of maturation on reading skills across such a large lifespan. Narrowing the groups to span the ages of 3 to 5 years will help diminish the confounding effects of maturation and help educators determine what methods are most effective for improving academic performance among pre-school children.

To date, no studies have been found regarding the effect of colored overlays on tasks required for reading, such as identifying or comparing symbols and letters, in pre-school children with or without disabilities.

This study will add to the literature by studying pre-school children both with and without disabilities, in a regular pre-school classroom, who may be helped to identify symbols or letters when using colored overlays. This could give teachers and parents an added tool to help facilitate reading skills during maturation.

This study also will introduce standardized colored overlays developed by Wilkins, Lewis, Smith, Rowland and Tweedie, (2001) and produced by Cerium Visual Technologies, Ltd, Kent, England. These overlays will be used to determine the color that each child in the study prefers. Assisting children to choose the preferred color (See Methods section) and covering text with the appropriate overlay can be done easily by classroom staff.

Limitations of the Study

1) The children with disabilities will not be separated on the basis of type or severity of disability. This will make the results difficult to generalize to children with a specific disability.

2) The procedure used by Wilkins, et al.,(2001) to determine the preferred color may require some adaptations to accommodate children who do not yet read and who have various disabilities.

3) The numbers of subjects will be relatively small, limiting generalization of the results.

4) Children may prefer a particular symbol as well as a particular color. Therefore it is not possible to say with certainty that all choices will be made solely on the basis of color.

Definition of Terms

1) Children with disabilities - Are defined as children who are receiving special education services and have a current Individualized Education Program (IEP).
2) Children without disabilities - Are defined as children who have not been identified as having a disability and who are not receiving special education.
3) Color preference - Is defined as the overlay remaining after all other choices of overlays have been eliminated.
4) Colored overlays - Are defined as sheets of acetate that are tinted with various colors.
5) Mainstream classes - Are defined as general education classrooms that include both children with and without disabilities.
6) Identifying symbols - Is the ability to look at an enlarged black symbol on a white card and point to the same symbol in a row of cards.
7) Specific reading disability (developmental dyslexia) - Is a disorder causing difficulty in learning to read despite the opportunity, adequate instruction, normal intelligence, and the absence of general health, emotional, hearing or visual impairments (Lovegrove, Garzia & Nicholson, 1990).

CHAPTER 2

REVIEW OF LITERATURE

Introduction

Research has shown that placing colored overlays over text material mediated visual processing in children with disabilities such as reading delays (Lovegrove, Martin & Slaghuis, 1986; Solman, Cho & Dain, 1991) specific learning delays (Evans, et al., 1999) and dyslexia (Christenson, Griffin & Taylor, 2001). It also has been demonstrated that a change in the contrast on a computer monitor helped to clarify any visual distortions that might slow reading speed and comprehension (Croyl, 1998).

The symptoms that were improved when colored overlays were placed over reading texts or computer screens included visual distortions such as movement of letters, blurring of vision (Irlen, 1983) or eye strain and headache (Wilkins, et al., 1991). These visual symptoms were not detected with routine optical examinations and were believed to be the cause of reading delays, even though the subjects were of average intelligence and had no other physical impairments.

Lovegrove, Martin and Slaghuis (1986), in a review of their experiments, demonstrated that a low-level visual deficit is present in a large percentage of children diagnosed as having a specific reading disability (SRD). Their experiments suggested that 70% of children with (SRD) had deficits in an area of the cortical visual processing system, the transient visual system.

Other studies have shown that these same visual deficits may cause losses in reading related skills for patients with cerebral lesions. Despite having good visual acuity, these patients continued to have difficulty with visual activities required for reading, such as focusing on small objects or symbols (Bodis-Wollner, 1972).

Irlen (1983) suggested that there were children and adults who were sensitive to certain frequencies of light at the retinal level. These visual distortions, particularly with the contrast of black print on a white page, led to ongoing academic problems such as reading and writing delays. Irlen coined this type of visual impairment as scotopic sensitivity syndrome (SSS) and developed a method for using transparent colored plastic sheets to diminish visual distortions. Although Irlen generated much public interest in the use of colored overlays to improve reading and other functional abilities, the information available primarily is anecdotal and will not be the focus of this discussion. However, other researchers have shown that reading performance can be improved in those with mental retardation (Meador, 1984), Down syndrome (Huang & Borter, 1987), and specific reading deficits (Wilkins, et al., 1994), by using color to contrast text from background or by using colored overlays.

The purpose of this chapter is to review and analyze the literature regarding the effect of colored overlays to improve certain skills required for academic performance in children with and without disabilities.

The first section will include information regarding the legislative, judicial and demographic influences upon the education of young children with visual impairments. From this information it may be inferred that academic delays can persist as children develop, despite cognitive and linguistic intervention. This suggests that other visual problems, that are not being addressed, may be causing academic delays.

The second section is a review of the studies suggesting that a visual impairment caused by a sensory/perceptual visual deficit in the visual cortex may be an unidentified cause leading to reading delays. These studies suggest that although standard optical examinations are important for all children, certain visual perceptual problems may not be identified with standard optical tests. It may be the reason why some poor readers, who otherwise are not academically delayed, have reading problems despite optical correction with eyeglasses. These studies also suggest that this unidentified problem may be helped with the use of colored overlays.

The third section is a review of studies on the impact of colored overlays on visual perception, reading speed and comprehension. Studies examining the effectiveness of preferred colored overlays versus randomly chosen overlays and clear overlays also will be presented. An efficient method of determine the preferred color that facilitates reading for each individual by using the Intuitive Overlay Instruction Book (Wilkins, et al., 2001) will be discussed. These studies suggest that allowing the individual to have a larger choice of colors for overlays would be more effective for improving performance than the use of a few basic colors for overlays.

The fourth section will examine the research involving those who have disabilities, other than reading disabilities and who have similar visual perceptual problems as those with reading disabilities. This infers that children with various disabilities may have visual perceptual deficits that may be diminished with colored overlays.

The fifth section is a review of the studies using overlays over computer monitors or changing computer monitor background colors and intensity levels to improve reading performance. This information infers that educators must consider not only the most frequently used reading strategies, but also ways of increasing the use of computer technologies to improve academic skills.

The reviews of the studies will include a statement of the purpose of the study and the research questions to be addressed, the subjects and methods employed, the results, the significance and potential benefits to be gained from the study and the limitations.

<u>Factors Influencing the Education of Children with Visual Impairment.</u>

In 1975 the Education for All Handicapped Children Act (EAHCA) was passed by Congress. Under this Act, States could receive federal funding for children with disabilities between the ages of 3 and 21. According to the EAHCA (1975) all children with disabilities must be given free, appropriate and individualized education in the least restrictive environment. In 1990 the EAHCA (1975) was amended as the Individuals with Disabilities Education Act (IDEA).

IDEA (2004) defines children with disabilities as those included among 13 categories and who need special education and related services. The 13 categories include mental retardation, hearing impairments including deafness, speech or language impairments, serious emotional disturbance, orthopedic impairments, autism, traumatic brain injury, other health impairments, or specific learning disabilities, and finally visual impairments including blindness (Rothstein, 1995).

The Department of Education (DOE) reported that between 1999-2000 over 500,000 preschool children with disabilities were served. Approximately 200,000 children received services under Part C, or 1.8% of nation's infants and toddlers (DOE, 2001).

Of the children entering early intervention programs in 1999-2000, approximately 8% were diagnosed with visual impairments, one of the 13 disability categories of the Individuals with Disabilities Education Act (DOE, 2001). The diagnoses of visual impairment were obtained by standard optical examinations. Generally eyeglasses were prescribed for only 2% of children receiving early intervention.

As will be discussed in Section 4, some of the problems encountered by children with other disabilities, including ADHD and learning disabilities, may be due to transient visual system impairment, a visual perceptual problem that may be covered under IDEA.

The DOE (2001) also reported that the percentage of students with specific learning disabilities increased with age, despite services in 1999-2000. For example, of the children receiving early intervention, 39.9% were diagnosed with specific learning disabilities (DOE, 2001) and visual impairments were commonly associated with specific learning disabilities (Evans, 1993). Among 12 to 17 year olds, 61.9% of the students were reported under the specific learning disabilities category, and among students 18 to 21 years of age 51.1% of students receiving services were in the specific learning disabilities category.

Experts in child development recognize the value of early intervention, especially for children with disabilities. The earlier these children are provided with programming that addresses their specific problems, the more likely it is that they will require less services later in life (Rothstein, 1995).

There is considerable disagreement over the types of services to which children with learning disabilities and ADHD are entitled, especially because their numbers are growing daily (Rothstein, 1995). As will be discussed in Section 4, in certain children with learning disabilities and ADHD the resultant problems may be caused by a visual perceptual disorder that is not detected with standard optical examinations and is not correctable with eyeglasses.

The statistics regarding the growing number of older children diagnosed with learning disabilities and ADHD highlight the need for solutions to the problems leading to academic delays at an early age. If it is assumed that cognitive or behavioral deficits are the underlying cause for academic delays, visual problems may be overlooked. This is particularly true with problems such as transient visual system deficits that generally go undiagnosed with standard optical examinations.

Transient Visual System Deficits

There are two main theories as to why children with reading disabilities, sometimes identified as children with specific reading disabilities (SRD), have visual deficits that impair their ability to process visual stimuli. These theories are the transient/sustained theory of visual perception (King-Smith & Carden, 1976) and the Irlen theory of the scotopic sensitivity syndrome (Irlen, 1983). As previously stated the Irlen theory of scotopic sensitivity will not be discussed in this paper because the information available primarily is anecdotal rather than empirical.

The transient and sustained visual systems are visual processing systems that are individual but work interactively. During normal reading, the transient system is the first to be activated. Information from the printed material is transmitted relatively quickly. The eyes move rapidly along the text and begin to process additional information from the next words on the page. The transient system responds to the visual stimulus onset and offset, and is more dominant in peripheral vision rather than central vision (Lovegrove, Martin & Slaghuis, 1986).

Following the activation of the transient visual system, the slower, sustained visual system is activated. The sustained system detects pattern information about stationary items, such as the details of letters. The sustained visual system responds throughout the duration of the stimulus. During normal reading the response of the transient visual system does not overlap with the response of the sustained visual system (Lovegrove & Nicholson, 1990). In other words, the eyes flow easily along a line of text rather than lingering on the previous word before progressing onto the next word.

When the transient/sustained systems are interacting normally, the transient system inhibits the sustained system. The inhibition of the sustained system by the transient system is particularly important for reading because the transient system affects the response of the sustained system by stopping the continuation of the sustained system. This prevents the previous fixation on one word from interfering with the succeeding fixations, so that the eyes can flow to the next word. Overlapping of fixation on one word before moving to the next word is prevented, thereby allowing the eye to move smoothly across the text. If the sustained system is not inhibited, two individual inputs may be seen simultaneously, making the text appear to be superimposed or overlapping (Lovegrove, Garzia & Nicholson, 1990).

Thus the transient system directs the eye to the location of the words on the page and the sustained system extracts the details of the letters. If the duration of the sustained system outlasts the physical duration of the eyes moving to the next word, there may be interference of the visual processing as the eyes move to succeeding words. The normal visual system solves the problem by the transient system inhibiting the sustained system during the first visual fixation on a word, thus preventing interference with the second fixation on the next word. (Lovegrove, Martin & Slaghuis, 1986).

It has been shown that impairment of this temporal separation between the transient and sustained systems can lead to selective attention deficits, longer visual search times, slower visual processing and impaired figure-ground perception (Brannan & Williams, 1988; Williams, LeCluyse & Bologna, 1990).

King-Smith and Carden (1976), were among the first researchers to establish that color vision was sub-divided into two visual systems (transient and sustained). They found that the sustained visual system mediated visual acuity and some color vision. The transient system mediated contrast sensitivity as well as flicker sensitivity and movement detection. In addition, they found differences between the red and green color receptors, that are found close to the fovea, when compared to the blue color receptors, that are found peripheral to the fovea. This suggested a separate form of division between the transient and sustained systems that was based on color detection.

Using a test flash method and by plotting the spectral sensitivity curves for each test, they found that the intensity and color of a background light could affect the detection of visual stimuli that was presented on a white background. Symbols on a white background is the situation generally occurring when reading from a book.

The subjects included two adults, 31 and 34 years of age. The subjects sat in an isolated room and observed pairs of test flashes. For example, one test flash was white while the second test flash was one of the colors represented by the cones on the retina (red, blue and green). Within a one second period the subjects were required to choose which of the pair was the colored stimulus. The probability of a correct choice of color was plotted against the intensity of the stimulus.

By looking at the interaction of the three types of cones that were present on the retina, the authors suggested that various wavelengths of light impacted differently on vision. For example, there were inhibitory interactions between the green and red sensitive cones, but no inhibitory interactions when the blue sensitive cones were stimulated. Since the blue cones were located outside of the fovea, and since acuity was decreased in blue light, their stimulation corresponded to transient system activation. In addition, they found that when different colored test flashes were presented, it took a longer time to integrate red and green colored flashes than the blue flashes. This suggested that the activity of a separate system, the sustained system, might be limited by reducing stimulation of the red and green cones.

This is a possible explanation as to why readers may have a slower reading time when text is covered with a red overlay and is facilitated when using a blue overlay as was demonstrated by Iovino, Fletcher, Breitmeyer and Foorman (1998).

The setting for this study by King-Smith and Carden was artificial. The head was restrained and test flashes were presented directly into the foveal area of the eye. Regardless, this research was one of the studies that set the stage for further examination of the visual color systems. Later studies would examine more functional activities such as reading and writing.

Mollon (1982) helped substantiate the findings of King-Smith and Carden (1976). Following anatomical studies Mollon suggested that the differences in the interactions of the red, green and blue color retinal receptors were due to the blue cones being located on the outside of the fovea. Stimulation of the blue receptors reduced acuity and seemed to stimulate the transfer of medium to low spatial contrast frequency information, a function of the transient visual system. In other words, blue receptors seemed to facilitate processing of words that had larger inter-spaces rather than smaller inter-spaces. Therefore, information that might not ordinarily be distinguished when words were closer together was more easily distinguished if the blue receptors were activated.

In 1986, Lovegrove, Martin and Slaghuis, in reviewing a number of their studies, confirmed that two processing systems (transient and sustained) were required for interpretation of visual stimuli. They studied children with specific reading disabilities (SRD), 8 to 15 years of age, who were of average intelligence and without behavioral or physical problems. Although these children were delayed in reading, they were not delayed in other academic subjects.

Three types of tasks were used in these experiments: visual persistence, pattern contrast sensitivity frequency (CSF) and flicker CSF. The results showed that the visual persistence tests were the best determinants of how well the visual measures discriminated between the SRD and typically developing children. Therefore, the experiments illustrating the visual persistence findings will be summarized rather than the CSF studies.

When reading, visual persistence is the tendency for the eyes to remain focused on a word or symbol rather than flowing to the next word or symbol. Visual persistence was measured by alternation of a stimulus pattern, such as a sentence, with a blank space. The transient system response is known to be of shorter duration than the sustained system response (King-Smith & Carden, 1976). When the sustained system response is not inhibited, the visual response of the sustained system may outlast the physical duration of the stimulus.

The experiments involved comparisons of visual persistence between subjects with specific reading disabilities (SRD) and those reading at the appropriate grade level. The duration of visual persistence was determined by measuring the stimulus intervals between alternating stimulus patterns (wave gratings) and blank fields. The inter-stimulus interval was varied until the subjects could detect a clear blank interval between two identical wave gratings. The length of the inter-stimulus interval was considered the measure of visual persistence. Measurements were taken in milliseconds and graphed.

Analysis of visual persistence and spatial frequency (the inter-stimulus interval) showed that 75.4% of children with (SRD) showed deficits in the transient system while the sustained system functioned normally. Generally, the children with SRD differed significantly from control subjects in transient visual system function, but not in sustained system functioning. Interestingly, 8% of the control group also demonstrated transient system deficits.

In addition, the subjects with SRD were affected more than the control subjects at lower spatial frequencies and were less sensitive to lower spatial frequencies (when the symbols were farther apart) than control subjects. In addition, they were at least as sensitive or more sensitive than control subject to higher spatial frequencies (when the symbols were closer together). In other words, at lower spatial frequencies the intervals were wider and the visual persistence was longer for the children with SRD than the normal readers.

This finding was consistent with the theory of two parallel visual systems. Standard acuity tests examine high spatial contrast frequencies that are under the control of the sustained visual system thus confirming the suggestion that visual acuity tests can be normal even though visual interpretation of symbols requiring the transient visual system might be impaired.

Thus, visual acuity tests may not identify impairment of the transient visual system because these tests measure the smallest resolvable detail frequencies of high spatial frequencies. It is possible that those with impairments at other spatial frequencies may have normal visual acuity tests while still having visual impairments in channels required for more complex visual tasks such as reading.

It was hypothesized that the longer persistence at low spatial contrast frequencies in subjects with SRD was the result of the inability of the transient system to inhibit the sustained system at the appropriate time. This allowed the sustained system to respond for longer than required and increased the persistence duration during reading. The differences in the visual persistence between subjects with SRD and control subjects at both high and low spatial frequencies is another verification of the interaction of the transient/sustained visual systems.

There was little evidence that the differences diminished with increasing age or general improvement in ability to read. This was demonstrated in another study by Lovegrove, Garcia & Nicholson, 1990). This study compared the relationship between visual sensitivity at age 6 and the reading ability at age 8. The results showed that the relationship of the slopes of visual persistence duration to spatial frequency did not change as children learned to read. This suggested that the visual deficits did not result from failure to learn to read but rather from a condition that existed before the children began reading.

The effect of maturation on those with SRD also was looked at in a longitudinal study by Rutter and Yule (1975). A comparison was made between the academic progress of children with SRD and of average intelligence with children who were poor readers who had lower IQ scores. Over a period of 4 to 5 years they found that the children with SRD made less progress in reading and spelling than the children who were poor readers with lower IQ scores. However, the children with SRD made more progress in mathematics than those who were poor readers with lower IQ scores. This suggested that academic delays in reading related subjects in children with SRD were unaffected by maturation or learning and may be the result of an organic cortical problem such as transient visual system deficit.

In 1988 Brannan and Williams performed two experiments on the impact of maturation on visual processing. The reading skills of typically developing children and children with reading disabilities were compared to determine if visual processing deficits would become corrected with development.

The subjects included 30 children aged 8, 10 and 12 years, and 5 adults. All of the children were of average or above average intelligence, as measured by the Stanford-Binet Test, and were performing at average or above average levels in all academic subjects, with the exception of reading and reading related subjects. Visual acuity was normal or corrected to normal with eyeglasses.

In Experiment 1 the subjects were asked to detect the temporal order of two briefly presented stimuli. The stimuli were presented on a computer with green letters or symbols on a dark background. The letter stimuli were a two- word sequence BOX and FOX. The two non-word symbols were [#] and [&].

The subjects sat in full view of the screen at a distance of 30 cm. Either the word stimulus or the non-word stimulus was presented on the right or left side of the screen. The subjects were asked to point to the side of the screen on which the first stimulus appeared.

The results showed that the children who were poor readers required significantly more time to make accurate judgments about the correct order of appearance of the two stimuli than the children who were good readers of the same age or the adults. This was true whether the stimuli were of the word or non-word type.

There was significant correlation between reading level and the ability to make these accurate temporal order judgments with all of the subjects. The 8 year old children who were good readers needed significantly less time to answer correctly than did the 10 year old children who were poor readers but were reading at the same level. This suggested that the difference in ability to make correct temporal order judgments was not caused primarily by differences with increasing age, but rather by a basic processing difference between the groups. Thus, the results suggested that a temporal processing deficit cannot be accounted for by developmental lag.

The purpose of the second experiment was to determine if the deficit in temporal processing also might lead to perceptual deficits. A more functional task of sorting cards on which were printed various combinations of brackets was used. The difference in the perceptual grouping effects between children who were good readers, children who were poor readers and the adults was examined. Strong perceptual grouping effects was believed to diminish the ability to rapidly distinguish between symbols such as groupings of brackets ([ ] vs. [[).

In this experiment, bracket symbols were drawn with black ink on white cards. The stimuli were arranged in four decks of 32 cards. Examples of the symbols included the control condition of [ ] vs. [[, and the orthogonal condition of [ ] or]] vs. [[or] [. The control conditions could be sorted on the basis of the overall shape of each pair of brackets. The orthogonal condition required selective attention because sorting occurred on the basis of variation in the right element of each pair of symbols. A color condition was included in which the four decks of 32 cards were marked with either blue or purple dots in the center.

Subjects were asked to sort the cards into two piles as quickly as possible. They were to focus on either the right or left elements that were printed on the cards, depending upon the conditions of the trial. Sorting time was measured with a stopwatch. If the subjects were able to selectively attend to the relevant elements, the sorting times for control and experimental subjects would be essentially the same for both the control and orthogonal conditions. The orthogonal condition was used as the index to measure the degree of perceptual grouping. If there were a problem with selective attention, sorting time would be longer in the orthogonal condition.

The results showed that visual processing differences did exist between the children who were good readers and the children who were poor readers. Significantly more time was required during the card sorting task for all conditions by the children who were poor readers, suggesting that they had stronger perceptual grouping effects.

Although the grouping effects became weaker with maturation, the magnitude of the difference between the groups did not change. This suggested that the differences in the visual grouping processes between the ages of 8, 10 and 12 were not affected by development. In other words, the differences in grouping effects did not lessen by age 12.

The reading levels and perceptual grouping effects also were significantly correlated between the groups. Pearson correlation indicated that 42% of the differences in reading levels were accounted for by the differences in grouping effects.

A results with the color condition showed that the overall sorting time of the children who were poor readers was slightly, but not significantly, faster than that of the children who were good readers. However, there was a significant difference across the ages with the color condition. The sorting times of the 8 year-old subjects were significantly slower when compared to those of the 12 year-old subjects, but the interaction of the two groups and the color conditions was not significant. This suggested that age related factors did not cause a change in the grouping effects with this particular color condition.

Prolonged grouping effects in the children who were poor readers was consistent with the suggestion that there were transient visual system deficits in some individuals who were delayed in reading. The finding that grouping effects do not improve significantly with maturation has important implications for the early intervention of children with reading problems since remediation would be more effective if focus were placed on the underlying cause of the reading delay.

Lovegrove, Garzia and Nicholson (1990) supported the suggestion that transient visual system deficits existed among children with specific reading delays. Five separate groups of children with SRD and children who were average readers, aged 8 years to 14 years, were compared. In this case, the experiments reported by Lovegrove, Martin and Slaghuis (1986) were duplicated with new subject groups.

The results showed that the subjects with SRD had increased visual persistence at low spatial frequencies (when the words were farther apart) than the control group. In addition, they had reduced contrast sensitivity to flicker stimuli than the control group. Flicker thresholds were determined by the number of times a light stimulus was flashed on and off per second. All of these findings were consistent with transient visual system deficits (King-Smith & Carden, 1976). These findings were found to occur in the beginning stages of visual information processing in reading. It was hypothesized that these deficits, when occurring at the early reading stages, might lead to interference with more advanced reading skills.

Thus the question arose as to whether transient visual system deficits existed before children began reading or whether the deficit was caused because the subjects with SRD were delayed in reading. To answer this question, a longitudinal study of the contrast sensitivity of 123 kindergarten pre-readers was performed. The mean age of the subjects was 5 years, 11 months. To ensure a broad sample of children with various achievement levels, all children in one classroom were tested.

The method included briefly presenting displays of sine wave gratings that were alternated with blank fields. Vocabulary and digit-span memory ability were tested at the outset.

Two years later the reading performance of these subjects was assessed using the Neale Analysis of Reading Ability. The results showed that contrast sensitivity was the most significant predictor of reading ability. The finding that the visual measure of contrast sensitivity was a better predictor of reading ability than either vocabulary or digit-span performance suggested that there was a close link between visual processing and reading ability. The results also suggested that visual deficits were not caused by a disability in reading.

The differences in low level visual processing between the children who were future good and poor readers that were present in the kindergarten pre-readers, prior to formal reading instruction, suggested that early diagnosis and intervention may be of benefit to children with transient visual system deficits. Intervention by adjusting to the special needs of these children prior to formalized reading instruction may help prevent later delays in reading.

In 1991, Solman, Cho and Dain tested the hypothesis that the use of colored lenses might assist children with reading disabilities by remediating deficits of the transient visual system. This study compared the visual perceptual grouping effects of 18 children with reading delays with 18 children without reading delays. Previously discussed perceptual grouping studies had shown impaired perceptual grouping to be consistent with transient visual system deficit (Brannan & Williams, 1988).

The subjects ranged in age from 8.07 to 8.14 years. All had normal visual acuity and similar general academic abilities.

Perceptual grouping baselines were obtained by performing the previously described card-sorting task of Brannan and Williams (1988). The task was performed without lenses and while wearing blue, yellow, gray, red and green optical framed lenses. There were a total of 36 trials in a single session. Each session lasted approximately one hour. The tasks required the subjects to categorize and sort the cards a rapidly as possible.

There were 2 holistic conditions and one selective attention condition. In the holistic condition, the basis of classification was the shape of a single symbol. In the selective attention condition, each pair had to be sorted according to the variation of the symbol on the right. The sustained visual system was required for the selective attention condition. Utilization of the transient visual system was required in the holistic condition. It was predicted that the two different activities would impact differently on the perceptual grouping effects between those with impaired and non-impaired transient visual systems.

The results indicated that both groups showed perceptual grouping effects. However, the grouping effects for the children with reading disabilities were much larger. In other words, the children with reading delays took longer to complete the selective attention card-sorting task than those without reading delays. The children with reading disabilities also experienced greater difficulty in moving from the holistic, low spatial frequency information to the selective attention, medium to high spatial frequency information. This is consistent with previous studies that found that children with reading disabilities had impaired transient system processing of low spatial frequency information (Lovegrove, Martin & Slaghuis, 1986).

The following mechanism was suggested from these results. One of the proposed functions of the more rapidly functioning transient system was to prepare the visual encoding system for the input of the slower acuity information with activation of the sustained system. If the transient processing were deficient, then acuity information also likely would be impaired. If the children with reading disabilities did not receive the transient information, as demonstrated in the holistic condition sufficiently well in advance, they would take longer than those without reading disabilities to sort the patterns on the basis of their detail. This proved to be the case as the sorting time for those with reading delays was significantly longer than the times of the control group.

Also, there were significant differences in performance between the groups depending upon the different colored lens types. There was a significant increase in size of the grouping effect among those without reading delays when blue lenses were used. However, grouping effects using any colored lenses, including blue lenses, showed no significant change among those with reading delays. This suggested that the blue lens had a negative impact upon those without reading delays that did not occur among those with reading delays.

It was hypothesized that among those without reading delays, blue filtered light could mediate transient visual system like activity. Restricting the incoming wavelength with a blue filter should increase the level of activity of the transient visual system and increase the grouping effect because of diminished inhibition of the sustained visual system. It also was hypothesized that the use of a blue filter might cause increased activation of the red and green cones thereby decreasing visual acuity.

Among those with reading delays, it was suggested that the process was reversed because use of the blue lenses reduced stimulation of the red and green cones leading to interference in distinguishing acuity information. Primarily, this would affect the selective attention sorting task by causing the sorting time during the selective attention condition to increase under the blue lens condition.

The above research suggests that a large percentage of children with SRD manifest sluggishness in the activation of the transient system while the sustained system appears to function normally. The basic problem seems to be a lack of normal temporal separation between the activation of the transient and sustained systems. The transient visual system deficit, while not affecting visual acuity, can negatively impact on the ability to effectively perform reading tasks. Of course, there may be other reasons for reading delays. However, since it has been demonstrated by Lovegrove, Martin and Slaghuis (1986) that 70% of the children with specific reading delays show deficits in the transient visual system, it should be considered that children with disabilities who have reading delays also may have transient visual system deficits. The problem may be alleviated with the use of color, as will be discussed next.

Colored Overlays

Even though Solman, Cho and Dain (1991) did not find that blue colored filters significantly improved the grouping effects in children with reading disabilities, they did establish a difference between the functioning of the transient and sustained visual systems in children who were good and poor readers. Other studies have looked at the impact on the transient and sustained visual systems in those with reading disabilities when using clear overlays and colored overlays of different hues.

For example, in 1990, O'Connor, Sofo, Kendall and Olsen looked at children with specific reading disabilities (SRD). The purpose of the study was to test the reading performance, i.e., rate, accuracy and comprehension, of children with SRD when they used preferred colored overlays as opposed to clear or randomly chosen colored overlays. The 92 subjects included 67 children who had been diagnosed with transient visual system deficits and 25 children who were not believed to have transient visual system deficits. Preferred colored overlays were defined as colored overlays that were determined by the students to eliminate most symptoms, such as blurring of vision, movement of letters or eye fatigue, thus making it easier to read.

The subjects ranged in age from 8 to 12 years and were in grades 2 through 6. All were of average of above average intelligence but were reading at least 18 months below grade level. This was well below their abilities in other scholastic areas. Two of the subjects were in a Junior Assistance Class, the Australian equivalent of a special education classroom. In Australia children who were identified at age 6 as being at risk for learning disabilities if left without special assistance in the mainstream classroom are placed in Junior Assistance Classes.

The children with reading disabilities who had transient visual system deficits were randomly assigned to four treatment groups. The groups were given either preferred colored overlays, clear overlays or overlays other than the preferred color. The remaining children with reading disabilities were assigned to two treatment groups and were given either clear overlays or colored overlays other than the preferred color. Pre- and post-tests of reading ability and comprehension were performed using the Neale Analysis of Reading Ability (Neale, 1966) and the Formal Reading Inventory (Wiederholt, 1986) respectively. The Neale Analysis of Reading Inventory consisted of six passages of prose for children aged 6 to 13 years. The passages, in black print, were on white paper rather than on colored paper.

The task was to place the colored overlay (preferred, clear or randomly chosen) over all reading material for both schoolwork and homework for one week. After one week the children were re-tested in both of the reading tests, using their preferred color overlays.

The results indicated that the children with reading disabilities who had transient visual system deficit showed significant improvement in reading rate, reading accuracy and comprehension when using the preferred colored overlays. This group gained an average of 6.6 months in reading rate, 6.9 months in reading accuracy and 19.35 months in reading comprehension. When these children were given clear overlays or overlays other than the preferred color, the improvement was more variable, i.e. some improved and some regressed. Those given clear overlays regressed in all three categories within the one-week period. For the children who did not have transient visual system deficits, no significant improvements were found with use of either the clear overlays or colored overlays other than the preferred color.

A similar study by Dbo, Sutherland and McGettrick (1992) compared children with specific learning delays (SLD), who also had visual perceptual dysfunction, to a control group when using preferred colored overlays during reading. Thirty-four subjects, 14 in the experimental group and 14 in the control group, were chosen. The ages ranged from 8 years to 13 years. All subjects had normal or corrected to normal vision with eyeglasses.

A series of perceptual tasks were performed with preferred colored overlays and without overlays. The Neale Analysis of Reading Ability was used to test reading rate, accuracy and comprehension in both the experimental and the control groups. The tasks were to read a test passage without an overlay. Immediately following, a different test passage of the same complexity was read using the chosen overlay. All passages on which the overlays were placed were presented with black print on a white background.

The results showed that there was an immediate and marked improvement in reading fluency of the experimental group. Subjective reports from the experimental group indicated that they experienced less eye strain and greater clarity when reading using the preferred colored overlays.

The subjects were supplied with their chosen overlays and were instructed to use them for reading. The Neale Analysis of Reading Ability was re-administered 4 to 12 weeks later. At this time the control group was asked to choose an overlay that they liked or one that improved the contrast between the background and the print the most.

Ninety-three percent of the experimental group increased their reading rate in the range of 2 to 29 months. With overlays the control group showed no overall benefit. In some cases members of the control group had reduced or unchanged reading rates along with diminished accuracy and comprehension scores.

Unexpectedly, 43% of the experimental group had a drop in accuracy ranging from 1 to 7 months and a decrease in comprehension of 2 to 28 months. It was hypothesized that this drop may have been the result of immaturity of word attack skills with the increased reading speed.

This study suggested that individuals diagnosed with specific learning delay had a visual perceptual problem that could be recognized and, therefore, treated. Unfortunately, only percentages and means of increase or decrease in reading ability were reported. There were no statistical analyses that would indicate significance of the results.

The increased reading rate, seemingly at the expense of accuracy and comprehension raised questions about possible causes that may be responsible for reading delays other than transient system deficits. It has been suggested that there may be confounding non-sensory factors involved with reading deficits such as the effects of attention. Brannan and Williams (1987) suggested that it was difficult to account for the effects of attention when it is demonstrated only at low spatial frequencies. Thus, it may be possible that attention may be affected differently at various spatial and temporal frequencies in children with reading delays.

To explore this possibility Iovino, Fletcher, Breitmeyer and Foorman (1998) compared the effect of colored overlays in children with reading delays, children with mathematics delays and children with attention deficit/hyperactivity disorder

(ADHD). Since the use of colored overlays had been documented as an intervention shown to be effective for remediating transient visual system deficits (Solman, Cho & Dain, 1991), this study included groups of children with disabilities other than reading disabilities.

In this study sixty children, ranging from 8 to 18 years of age, were assigned to four separate groups. The groups were: reading-spelling-arithmetic disabled (RSA); reading-spelling disabled (RS); arithmetic disabled (A); attention deficit/hyperactivity disorder without learning disabilities (ADHD). Attempts were made to control for the influences of attention by having the children with ADHD take their medication during the experiment. All the subjects in the first three groups scored below the 30th percentile on reading, spelling and arithmetic tests.

Upon initial testing, all four groups were significantly different on the three achievement measures, reading, spelling and mathematics. The ADHD group scored significantly higher on the reading, arithmetic and spelling than the RSA and RS groups, but did not score significantly higher on spelling than the A group.

During the experimental procedure, the subjects read aloud from black lettered texts that were covered with red, blue or no overlays. The reading tests included a word recognition task and a reading comprehension task. Response times and reading times were measured for both tests with the three types of overlays.

The procedure started with the reading recognition task. This task has been shown to require the least amount of involvement of the transient visual system

(Williams, Lecluyse & Rock-Faucheux, 1992). The subjects were asked to read aloud from a list of words. The individual lists were placed on separate pages. With each of the colored overlay conditions (red, blue or no overlay) the lists were changed, but were of comparable difficulty. For each colored condition, the accuracy and rate of reading were calculated.

During the reading comprehension task, complete, short passages of text were presented. This task required free-eye movement and placed the most demands upon the transient visual system (Williams, Lecluyse & Rock-Faucheux, 1992). Once again the passages to be read under the separate colored conditions were changed, but were of comparable difficulty. The subjects were asked to read the passages aloud while the reading rate was timed in seconds. Reading accuracy was determined by calculation of a standard score for the total number of comprehension questions answered correctly.

Analyses of the results were conducted to determine the effects of the overlays on accuracy and rate of reading for both the reading recognition and reading comprehension tasks. The analyses of the initial baseline reading comprehension rates between the groups showed that the ADHD and the A groups scored significantly higher than the RSA and RS groups. The ADHD and A groups did not have reading delays.

Analysis of the reading recognition task, that required minimal transient visual system processing, showed that the initial level of reading skills differed significantly between the groups. No significant improvement in reading rate was to be expected since this task placed the least demands upon the transient visual system. Thus, even if the subjects had transient visual system deficits, they still might be able to perform the reading recognition task at normal rates. The results showed that this was the case for all groups with the exception of the ADHD group that had significantly improved reading recognition with the blue overlays.

Generally, the results after performing the reading comprehension task with overlays showed that the blue overlays significantly improved reading comprehension when compared to the red overlays or no overlay in all groups, with or without reading delays. At the same time, Pearson product moment correlations showed a moderate negative correlation between rate of reading and reading comprehension. Once again this indicated that, under all three colored overlay conditions, reading comprehension improved when reading rate slowed.

When looking at the influence of ADHD on reading performance, the results varied from the non-ADHD groups. There was a significant interaction between ADHD and color regarding reading comprehension. However, the significant effects on reading comprehension in the ADHD group were produced with the red colored overlays as well as the blue overlays. It should be remembered that the ADHD group did not have reading delays.

As previously indicated, the red overlays did not significantly affect reading comprehension among the non-ADHD groups. However, blue overlays did significantly improve reading comprehension in the non-ADHD groups. These are significant findings in two ways. First, red overlays have been found to have no effect or negative effects of reading performance in children with reading disabilities (Williams, Lecluyse & Rock-Faucheux, 1992; Croyle, 1998), which does not appear to be the case with children with ADHD. Second, blue overlays improved reading comprehension in children with reading delays and children with ADHD who did not have reading delays. In both cases there was a concurrent decrease in reading rate.

These results suggest that systems other than the transient visual system may be affected with the use of colored overlays. The interaction between the ADHD group and color on the reading recognition task varied from the other experimental groups by showing significant improvement using the blue colored overlays. It would be expected that the reading recognition task that required minimal activation of the transient visual system would be unaffected with the use of overlays in the reading disabled groups. This was not the case with the children with ADHD. In addition, the finding that use of the blue overlay significantly decreased reading rates while at the same time increasing reading comprehension suggested once again that processes other than the transient visual system activation might be affected. It was suggested that one of the other factors to be considered might be increased attention that is given to the text with slower reading rates.

In summary, the results of this study showed that blue overlays significantly increased reading comprehension performance while rate of reading was reduced in both children with reading delays and ADHD. The effect of the use of overlays on attention were suggested because, unlike other reports, children with

ADHD showed improvement in reading comprehension with red overlays as well as improvement in the reading recognition task with blue overlays.

To help resolve the controversy of why different colored overlays had different effects, Wilkins, et al., (1992), described the development and testing of a system of tinted lenses that would allow for a broader choice of colors from which subjects with visual perceptual problems could choose. It previously had been shown that when individuals were allowed to choose from a range of colored overlays, the preferred choice varied considerably (Solman & Cho, 1991; Brannan & Williams, 1988). This color system was designed to provide a broad range of individuals with colors that were different enough so as to provide maximal visual comfort and reduce perceptual distortion for each person.

This system, called an Intuitive Colorimeter, was based on the premise that colors existed in three intuitive dimensions (hue, saturation and brightness). The Colorimeter consisted of a wheel that was divided into three sections. Each section had a different color. When a light was transmitted through the wheel, the three sections of the wheel could be revolved to mix multiple colors. The penetrating white light also could be varied and filtered so that the dimensions of hue, saturation or brightness could be changed individually. This allowed for production of a continuous range of colors, rather than discrete basic colors, from which to choose. It was hypothesized that with a particular hue and saturation certain individuals would report a decrease in perceptual distortions when reading.

The subjects included 22 children with reading difficulties who reported perceptual distortions such as instability of words or letters, letters "wobbling" or letters "moving about". Most of the children complained of migraine headaches or had family histories of migraine.

The subjects viewed the text to be read through an aperture in a box. Light was passed through the colored disc and was scattered onto the white inner surfaces of the box that could be seen through the aperture. The text consisted of random letters arranged in strings of one to seven letters.

The children were asked to vary the hue, saturation and luminance in order to obtain a color setting that most reduced their perceptual distortions. This was done by rotation of the disc within the beam of light. The colors most often chosen were rose, orange, yellow, green, turquoise, blue and purple. The chosen overlays that reduced the symptoms the most were inserted into eyeglass frames.

The results indicated that certain colors caused discomfort for most of the children. These were usually colors that were complementary to the colors that reduced the symptoms. Those with migraine generally chose colors complementary to red.

An additional consideration included in this study was that there might be color distortions when using overlays while looking at surfaces that reflected multiple color wavelengths, as when looking across a room. To explore this issue, nine children aged from 12 to 16 years of age with severe reading disabilities were assessed when viewing large numbers of different surfaces in the environment with lenses from the preferred Colorimeter settings. The results showed that, within limits, colored surfaces in the surroundings when viewed through the tinted lenses looked more or less normal. This result may have broader implications for the use of tinted lenses and overlays with individuals other than those with reading delays, e.g. balance problems.

A separate group of 108 subjects were studied while they read text and observed a normal scene when wearing trial tinted lenses. The results showed that subjects had decreased discomfort and distortion not only when reading but also when looking at a natural scene during daylight.

Interviews with children with reading disorders showed that they had an improved attitude toward reading and increased reading times without eye strain or headache when using the tinted lenses. Although the latter report was anecdotal, in conjunction with the former report of children viewing a natural scene that appeared normal when using tinted lenses, the question of the advantageous use of tinted lenses for daily activities by those with disabilities other than reading disabilities may be raised.

To investigate the impact of overlays on a general population of students, Jeanes, et al., (1997), examined the use of colored overlays in a regular classroom. Several different experiments were conducted with different groups of children. The purpose of these experiments was to determine the range of colors optimal for overlays and to look at the benefits from continued use of the overlays. Predictions also were made regarding which children would be likely to benefit from the use of colored overlays.

In the first study, the subjects included 93 primary school children aged 5 years, 5 months to 11 years, 2 months and 59 secondary school children aged 11 years, 4 months to 12 years, 3 months.

The Intuitive Overlay Instruction Book that was developed from studies with the Intuitive Colorimeter was used to help determine the optimal color choice. The Rate of Reading Test was adapted by choosing 110 of the most common words found in children's reading books. These words were arranged as a random meaningless passage. Each passage had 10 lines with 15 words on each line. The type was nine-point and the lines were more closely spaced than in other reading tests such as the Neale Analysis of Reading. The subjects were asked to read the words aloud, as quickly as possible, with and without the preferred colored overlays. Each session was tape-recorded. The readings were timed and the errors were counted.

The results showed a consistent preference for colored overlays by certain school children. The most frequently chosen color was mint green. The least chosen color was lime green. The most frequently chosen combinations were lime green/yellow, rose/orange and orange/orange. The least chosen color combinations were pink/purple and blue/aqua. Testing using the Rate of Reading Test showed an overall increase in reading speed. Fifty-one percent of the primary school children and 54% of the secondary school children reported beneficial effects when using their chosen overlays or combination of overlays.

There were two follow-up studies at 3 months and 10 months. The results after 3 months showed that 89% of the primary school children and 75% of the secondary school children continued to use their chosen overlays. The reliability and consistency of the color choices were analyzed between the initiation of the study and at the 3-month follow-up. The colors chosen at initiation were highly consistent with the colors chosen at the 3-month session. This suggested that mediation of transient visual system deficits with colored overlays is highly individual and the use of only the basic colors of red, blue and green may not achieve positive results.

At ten months 32% of the primary school children continued to use the overlays and read the randomly ordered simple words more quickly. Those who did not continue to use the overlays had poorer reading results. Nine percent of the secondary school children continued to use overlays. Children who were tested with gray or clear overlays read more slowly than those who used colored overlays. This suggested that a reduction in contrast was not the single critical factor in improving reading.

To test the possibility that any contrast, not necessarily colored contrast, may improve reading ability, 21 children were tested in 5 different conditions. The ages ranged from 7 years, 3 months to 14 years, 7 months. Using the revised Rate of Reading Test the subjects were tested with no overlays, with a gray overlay, with a clear overlay, with the preferred overlay and with an overlay complementary to the preferred color overlay. The results showed that the rate of reading with the colored overlays was significantly greater than with the clear, gray or no overlay. Since the gray overlays reduced the contrast of the text by an equivalent amount as the colored overlays, once again, reducing contrast alone did not appear to be a critical factor in improving reading.

Analysis of a separate group of children was used to predict the long-term usage of the preferred colored overlays. The subjects were 38 children who ranged in age from 8 years, 8 months to 11 years, 9 months. All of the children were issued preferred overlays or preferred combinations of overlays. The children were divided into two groups. One group was tested with the preferred overlays and the other group was tested without the preferred overlays at 3 weeks and 6 weeks.

At the end of the term the children who were given their preferred overlays were divided into two groups of those who continued to use their overlays frequently and those who did not frequently use their overlays. Those who used their overlays for most reading tasks showed a highly significant increase in reading speed on the first test session. Those who did not use their overlays frequently showed no significant increase in reading speed. These results indicated that the increase in reading speed with the use of the preferred colored overlay could be used as a predictor of which children would continue to use their preferred overlays in the long term.

Overall these studies demonstrated that the children who continued to use the preferred overlays over the long-term improved in reading rate by approximately 8 percent. It also was estimated that approximately 30 percent of children who were referred to the Institute of Optometry (where the subjects were recruited) found colored overlays helpful even following conventional treatment such as corrective eyeglasses and eye exercises.

Frequently, prescribed lenses or eye exercises would restore optic function to normal. However, in some cases the reading difficulties persisted even after the orthoptic function had been normalized (Evans, 1993). To determine the frequency of use of conventional interventions such as eye exercises, spectacles and colored overlays or precision tinted lenses, Evans, et al., (1999), made a retrospective study of 323 patients with specific learning difficulties. The children also had symptoms of visual perceptual distortions, visual discomfort and problems with binocular vision.

The records of all patients seen in the clinic over a 14-month period were reviewed along with the type of management that was used for each subject. The ages of the patients ranged from 4 years, 1 month to 73 years, 7 months. The mean age was 14 years, 9 months. Patients were tested with the Intuitive Colorimeter if they demonstrated a benefit from colored overlays. Approximately 18 months after the last clinical appointment, telephone interviews were conducted to confirm the continued use of the various interventions.

The summary of treatment regimens prescribed to reduce symptoms showed that 50% of the patients were issued colored overlays or tinted lenses, 48% had conventional optometric intervention and 22% received no optometric treatment.

The telephone survey showed that of the 57 subjects who responded and had been issued colored overlays, 60% used the overlays at least once a day, 32% never or rarely used them and 9% used them once a month or once a week. Of the subjects who received precision tinted spectacles, 82% used them daily. Regarding the other management regimens, 40% of the patients who had been helped with eye exercises continued to have symptoms. In this group, the symptoms were helped by the use of colored overlays.

Follow up interviews up to one and a half years later showed that 73% of those who had been prescribed with precision tinted spectacles continued to use them daily. This suggests that taking the time to accurately prescribe preferred colors may result in long term and successful use of tinted spectacles.

Inclusion of children with disabilities in regular classrooms is encouraged in the United States (IDEA, 2004) and also is common in Britain. Wilkins, Lewis, Smith, Rowland and Tweedie (2001) studied the changes in perceptual problems when using colored overlays during reading with children in mainstream schools*.

There were three aims of their experiment. Study I investigated the reliability of the preferred choice of overlay color and increase in reading speed. Study II investigated the relationship between visual difficulties with reading and scholastic, phonological and non-phonological reading strategies. Study III investigated the findings with a larger sample of a younger age group for predicative purposes.

---

*An email communication with Dr. Arnold Wilkins revealed that specific numbers of children with disabilities in these classrooms generally was 10% to 15% of the total classroom population. The diagnoses of the children with disabilities was not recorded.

Study I included 89 children ranging in age from 8 years, 6 months to 10 years, 6 months. Each subject was tested twice using the color sets from the Intuitive Overlays (Wilkins, 1994). To assess reading ability the subjects compared text on white paper with identical text that was progressively covered by ten different colored plastic overlays. The overlays were placed over the text singly, or neighboring hues were placed on top of each other. The first testing session was a group testing. This was followed by individual testing.

The procedure included issuing a page to each student on which was printed a passage of randomly ordered common words. The passage consisted of 20 lines with 15 common words in different random order. The 15 words were easily recognizable by the age groups tested. The words included "come, see, the, play, look, up, is, dog, cat, not, my, for, and, you, to".

The children were asked to read the passage aloud as quickly as possible for one minute in order to tire the eyes. They then were given a questionnaire regarding visual symptoms such as blurring of letters, movement of letters, clarity of letters placed on a horizontal board or presence of headache.

The results showed that 87% of the subjects chose the same preferred color during both test sessions. There was an overall increase of 11% in reading speed with the chosen overlays. Children who reported many symptoms tended to be those who chose the same overlays during the group and individual tests along with having the greatest increase in reading speed. For most of the children, the group screening techniques had similar results as the individual testing results. In general, the overlays improved reading speed by more than 30%.

The same procedures were used in Study I and Study II. However, in Study II the children were given overlays selected at random rather than the preferred overlays. This was done to study the specificity of the effects of preferred colors. A test also was designed to compare phonological or non-phonological processing strategies with visual processing. Also, in Study II, two separate word lists had to be read aloud. One list consisted of 40 phonologically regular words and the second list was of 40 phonologically irregular words such as “yacht”, and “meringue”.

The subjects included 378 children ranging in age from 8 years, 2 months to 12 years, 1 month. After reading aloud for one minute, to fatigue the eyes, the children were questioned about their symptoms. Then three identical word lists were placed flat on the table. The center list was white and the lists on either side were covered with overlays. The children were asked which of the three pages were the clearest. They then were asked to read aloud from the Rate of Reading Test, once with a white page, once with the page covered with the preferred overlay and once with the page covered with an overlay of a color chosen at random. Finally, the children were asked to read aloud without an overlay from two lists of words that were graded in difficulty. The first list was of phonologically regular words while the second list was phonologically irregular words. In addition, a gray overlay was given to 150 children while 100 children received a colored overlay chosen at random.

The results showed that reading time with the preferred color overlay was significantly faster when compared to the reading times with no overlay. There also was a small but significant increase in reading speed with the preferred color overlays when compared to the reading times with the randomly chosen overlays. The children who chose the gray overlay on the first test showed no significant increase in reading speed. Improvements in reading speed were greatest when the randomly chosen overlays were the same as the preferred colored overlays.

In Study III, 426 students from 12 different schools were tested. The ages of the students ranged from 6 years, 10 months to 8 years, 6 months. In addition to the Intuitive Overlays and the Rate of Reading Test, the Young's Group Reading Test was administered. The latter test required children to comprehend short sentences and identify a missing word from among four alternatives.

The overall results from Study III showed that approximately 50% of the children had improved clarity of the text with the use of colored overlays. Although no color clearly dominated preference, the individual choice of preferred color was reliable at re-test. The most frequently chosen preferred colors were rose, and aqua. Gray was infrequently chosen suggesting once again that the color is more important in reducing symptoms than a reduction in contrast (Jeanes, Busby, Martin, Lewis, et al., 1997). The results also indicated that the preferred color gave the greatest improvement in reading ability.

The practice effects over the course of the three studies indicated that the effect was greatest during Study I and negligible for the last two studies. The

Rate of Reading Test showed high test-retest reliability as demonstrated by high correlations between the first and second studies. This suggested that the Rate of Reading Test reflected individual differences and may indicate that the increase in reading skills with overlays, plus using this Test, may have some predictive use.

In general, these three studies showed that there was a clear consistency in the proportion of children in mainstream schools who reported beneficial perceptual effects with the use of colored overlays. The choice of preferred color for the overlays was highly individual, but also highly reliable. Most important, the use of the preferred color chosen for the overlay resulted in the greatest improvement in reading fluency.

For the educator, this study suggested that the use of a simple questionnaire about symptoms when viewing text will identify approximately 80% of the children that might be helped with colored overlays. Thus using a questionnaire with a group may effectively target those in a class that may benefit from individual testing.

In summary, two studies in particular have shown that the effects of color are not isolated specifically to children with reading disabilities. Iovino, Fletcher, Breitmeyer and Foorman (1998) showed that color affected the comprehension of children with ADHD who did not have reading delays. Wilkins, Lewis, Smith, Rowland and Tweedie (2001) studied children in mainstream classes who may have had additional diagnoses other than reading delays. These studies suggest that colored overlays may affect cognitive processes other than the transient visual system and may impact on the academic performance of children with disabilities other than those with reading disabilities. Only two studies were found that included children under 6 years of age. These were the studies of Jeanes, et al., (1997) and Evans, et al.,(1999).

Visual Discrimination in Those with Disabilities Other than Reading Disabilities

Several disorders that affect the cortical visual pathways can diminish the ability to distinguish between foreground and background without affecting visual acuity. It has been demonstrated that some individuals with disabilities other than reading disabilities, such as cerebral lesions or multiple sclerosis may have such a deficit (Bodis-Wollner, 1972; Raymond, Ginsburg & Murray, 1981). These authors suggested that an impairment of the transient visual system may cause a deficit in distinguishing contrasts between foreground and background and may lead to difficulties with reading. The following review of studies demonstrates that this impairment may exist in those with multiple disabilities and may go undetected because of not being identified with standard visual acuity tests.

Visual acuity scores are the generally accepted benchmark for visual competence. Acuity is measured with fixed charts containing test figures that decrease in size. The figures are black and sharply contrasted on a white background. Under normal conditions, if the test figures are reduced in contrast, i.e., different shades of gray rather than black and white, it is more difficult to detect the test figures. Standard visual acuity tests do not measure this sensitivity to contrast in color (Bodis-Wollner, 1972).

Bodis-Wollner and Diamond (1976) investigated adult patients with cerebral lesions, such as brain tumors, and showed that even with normal visual acuity they continued to have problems with everyday visual tasks such as reading. Similar findings were demonstrated by Lovegrove, Martin and Slaghuis (1986) in children with specific reading delays.

To establish a probable connection between cerebral lesions and uncorrectable blurring of vision, Bodis-Wollner and Diamond (1976) recruited 35 patients with known cerebral lesions who also complained of recent onset of blurred vision. Subjects without disabilities from ages 18 to 56 were the control group. The patients had such lesions as subacute bacterial endocarditis, intracranial space occupying lesions, meningiomas and other growths in the occipital lobe areas. None of the patients had impaired visual acuity scores.

Contrast sensitivity is the ability to distinguish between contrasting dark grids against a white background. To measure contrast sensitivity, vertical gratings were generated on a cathode ray tube in a sinusoidal pattern. A similar technique was used by Lovegrove, Martin and Slaghuis (1986) to test contrast sensitivity in children with specific reading delays. The width of the vertical grating bars was fixed. Measurements were taken to find the minimal contrast between light and dark bars that were required to distinguish the pattern. The spatial frequencies were established by changing the width of the bars. The contrast sensitivities of the patients and the control group were plotted on visuograms and compared.

Patients were seated in front of the visual stimulus display and given a 10 minute period to adapt to the environmental light conditions. Usually the eye contralateral to the lesion was tested while the opposite eye was covered. The patients looked at different contrasts of a grating from the same distance. After threshold readings were established, gratings with different spatial frequencies were cycled on a screen in randomized order. The task was to say "yes" or "no" to the presence of absence of the grating. In other words the subjects had to be able to distinguish light and dark contrasts of the different width bands.

The contrast sensitivity curves of the patients with cerebral lesions were compared with those of the 10 subjects without disabilities. The results showed that 31 of the 35 patients with blurred vision had profound changes in contrast sensitivity. Another important finding was that the deficits in contrast sensitivity occurred without changes in visual acuity as measured by standard visual acuity tests. The authors suggested that perceptual deficits, as indicated by loss of contrast sensitivity, lead to problems in activities involving more complex visual stimuli such as those required for reading.

It also was suggested that there were parallel pathways in the visual system that respond differently to different visual requirements. Thus, the pathways used to determine contrast sensitivity may be disrupted by cerebral lesions without affecting visual acuity pathways. The colors used to determine contrast sensitivity were black, white and shades of gray. The colors represented on the retina are blue, green and red and the impact that the colors might have upon contrast sensitivity or blurring of vision was not explored in this experiment.

Raymond, Ginsburg and Murray (1981) also did a study looking at contrast sensitivity and visual acuity in adults with multiple sclerosis. This experiment compared subjects' ability to accurately discriminate between pairs of letters using the Snellen test. The Snellen test is the commonly used visual acuity test with letters of gradually decreasing size.

The subjects included 7 females with multiple sclerosis, aged 21 to 53 years and 4 male and 5 female control subjects, aged 17 to 33 years. The chosen subjects had loss of the ability to distinguish contrasts in one eye, but not in the other eye. However, both eyes had the same visual acuity according to the Snellen test.

Letter discrimination was measured by two methods. Slides of letters first were passed through a green filter to minimize any color differences between the projector lights. The letter intensity was kept constant while the viewing distance was changed. The second method was to project a sine wave grating (bars of dark and light contrast) onto a screen. The task was to discriminate both where the letters appeared on the screen and the dark and light contrasts of the sine wave gratings. As the duration increased, and the longer the patients looked at the dark and light contrasts, the ability to discriminate decreased.

The results also showed that the visual acuity did not change with different viewing distances for the patient group or for the control group. In addition, the ability to discriminate the shapes of ordinary letters did not improve even with magnification of the letters. This deficit could not be predicted from visual acuity measures.

In summary, some patients with multiple sclerosis have similar visual deficits such as problems with letter recognition and contrast sensitivity, as those found in children with transient visual system deficits.

The visual symptoms common to specific patients with multiple sclerosis and those with specific reading disabilities include poor discrimination of printed letters or symbols while having normal visual acuity. This suggests that transient visual system deficits may be present in both of these groups and that color may have an impact on the visual deficits of those with disabilities other than reading delays.

Meador in 1984 studied the effects of color on the visual discrimination of graphic symbols in profoundly mentally retarded individuals. The purpose of the study was to use a non-speech communication training system by manipulating graphic symbols to improve attention and to develop a procedure that would facilitate discrimination with the use of color.

All of the subjects, 10 males and 10 females, participated in three experiments. The mean mental age of the subjects was 1.92 years. The mean chronological age was 23.17 years and the mean social age was 4.25 years. The tests used to determine these baselines were the Cattell Infant Intelligence Test, the Stanford-Binet Intelligence Scale and the Vineland Social Maturity Scale.

In all three experiments the stimuli were white drawings of geometric designs that were mounted on black or colored paper and placed on rectangular pieces of plastic. The drawings were of nine geometric graphic symbols. The designs were used singly or superimposed in combinations. There were 22 different colored backgrounds. Only one pair of hues (red and blue) was used during the training period. In each experiment there were criterion trials as well as test trials.

The subjects were divided into two groups based upon the number of correct responses given during the training period. One half of the subjects were assigned to the "high group" and the other half were assigned to the "low group". One half of the “high group” and one half of the “low group” were assigned randomly to the black background group. The remaining subjects were assigned to the colored background group. All of the subjects were trained to achieve the same criterion with the drawings on black backgrounds as well as on the 22 different colored backgrounds. The subjects were instructed to find a target picture among a random group of pictures. When the correct picture was chosen both a social and food reward were given.

Training sessions preceded the test trials so that each subject reached criterion levels in choosing the correct drawing. There were no significant differences between the black background group and the colored background group in the ability to reach criterion levels.

In Experiment 1 the symbols were on both the colored backgrounds and the black backgrounds. During the test trials there was a significant difference in the number of correct responses between the black background and the colored background groups. In addition, training with the drawings on colored backgrounds did not transfer to the same test trials with the drawings on black backgrounds. This suggested that discrimination occurred because the subjects learned the color rather than the form.

Because of the lack of transfer in Experiment 1 by the colored background group, in Experiment 2 the color was applied to the drawing itself rather than the background to determine if the application of color to the drawing instead of the background facilitated discrimination. As in Experiment 1, the application of color to the drawings greatly facilitated visual discrimination.

The results showed that discrimination training with randomly colored drawings did transfer to the test trials with black drawings. The subjects in the colored background group performed at a higher level than did the subjects in the black background group. This suggested that there was a facilitatory effect with the random application of color to the drawings.

It also was suggested that color applied to the drawings added an irrelevant dimension that increased the attention of the colored background group to the relevant cue. The addition of color increased attention and learning as demonstrated by the transfer to the test trials with the black drawings.

The third experiment essentially was a continuation of Experiment 2. Training to recognize distinctive features of a drawing that were colored was compared to recognition when colors were applied to the entire drawing.

The results showed that the performance of subjects given distinctive feature training with colors randomly assigned only to one segment of the drawing was higher than the performance of individuals given training with color randomly assigned to the whole drawing. There also was a higher level of transfer to drawings on a black background when color was randomly assigned to colored single segments.

Thus, the use of color seemed to be more helpful in distinguishing single segments in a drawing rather than distinguishing the whole colored drawing. In addition, embedding the colored segments within the black segments of highly similar drawings was critical for the transfer of identification to the same drawings in black. Generally, the results indicated that placing color on the symbols themselves rather than on backgrounds facilitated non-speech communication in profoundly mentally retarded individuals.

During the same period Winters and Hoats (1984) compared persons with and without mental retardation on their retention of printed material when one item was isolated from the other items by color.

The subjects were 18 institutionalized persons with mental retardation and 18 persons who were not mentally retarded. The mean age of those with mental retardation was 18.24 years. The mean age of the group without mental retardation was 18.16 years. Control groups were included in the study.

The procedure was to place selected nouns in nine horizontal lists with nine words in each list. The words in the control list were in blue with the middle word in red. The subjects silently read the lists at their own pace after which the screen went blank and the subjects were asked to recall as many words as they could from the list. They were given 15 seconds for the recall task.

As expected, comparison of the subjects who were and were not mentally retarded showed that the group who were not mentally retarded recalled a higher percentage of words correctly than those who were mentally retarded. A higher percentage of items were recalled from the beginning and ends of the lists than in the middle portions. Recall of the word isolated in red was greater for all subjects. There was no decrease in the recall of the remaining words of the sentences containing the isolated red item. This experiment clearly indicated that items isolated by color and presented in a sentence-like format were recalled better than when not colored.

The advantage of this type of isolation effect with the use of color also was demonstrated in adults with Down syndrome (Huang & Borter, 1987). The purpose of this experiment was to investigate the isolation effect in institutionalized adults with Down syndrome by determining the effect of attention on memory.

The subjects included 22 males and 18 females. Most of the subjects had been institutionalized since childhood. An experimental and a control group were formed and matched for gender, chronological age and length of institutionalization. All subjects had normal color vision.

Selective attention was manipulated by introducing a single brightly colored stimulus in a serial list of black and white items. The materials used were 10 hand drawn pictures, 35 x 40 cm, of common objects such as a ball, a bed, a bird, etc. One set of pictures was black and white and another identical set was in vivid color. The control subjects viewed the 10 pictures in black and white. The experimental subject viewed the same 10 pictures in the same order with the exception of the 6th picture that was in vivid color. The object was to determine if, during free recall, they remembered better the information to which they paid more attention, assuming that this was the colored picture.

The results demonstrated that the colored picture was recalled more frequently by the experimental group than by the control group. However, the overall recall was not significantly different between the two groups. Nevertheless, the results confirmed the hypothesis that selective attention can be enhanced by highlighting an object in a series with color in those with Down syndrome.

The above studies confirm that the use of color to highlight stimuli can impact on memory and learning in individuals with a variety of disabilities. To date no studies have been found that look at preschool children with disabilities, other than reading disabilities, and the use of color to improve reading performance.

Computers and Color

The fifth section will review studies concerning reading performance when colors are changed on computer monitors. The methods used in these experiments have included placement of colored overlays over computer monitors or changing the colored backgrounds and intensity levels of the monitors.

Transient and sustained visual system deficits can be remediated when the activation of the timing balance between the two systems is restored (Lovegrove, Martin & Slaghuis, 1986). Placing colored overlays over text has been shown to be one way of restoring this balance. Another method is to decrease sustained visual system activity by decreasing visual acuity with mildly diffusing plastic overlays (Breitmeyer & Ganz, 1976).

For example, Williams, Brannan and Lartigue (1987) covered a computer monitor with frosted clear overlays to cause blurring of the text. The purpose was to determine if the reading performance of poor readers with transient visual system deficits could be improved.

The subjects included 5 adults and ten, 8 to 10 year old children who were classified as good and poor readers. Classification of subjects was based on the Spache Diagnostic Reading Scales. Those scoring one year above grade level were classified as good readers. Those scoring one year below grade level were classified as poor readers. All children were of average or above average intelligence with corrected to normal visual acuity.

The subjects were presented with a visual search task that closely resembled typical reading operations. They were instructed to scan each line of a visual array that was presented on the monitor of an Apple IIE computer. The lines were read with and without overlays. The task was to read the text as quickly as possible by scanning the visual array from left to right and find a specific letter. When the correct letter was found, a response key was pressed. There was no testing prior to the experiment to assure that the physical response time required to push the response key was essentially the same for all of the subjects.

The results indicated that the search time for adults was unaffected by overlays. For children who were good readers, the search times decreased slightly but matched those of the adults. For children who were poor readers, there was a marked improvement in performance under the blurred condition that allowed them to achieve scores that were comparable to the good readers. When the image was sharp, the condition without the frosted clear overlays, the poor readers showed significantly longer search times.

The authors suggested that the performance of the poor readers was associated with a sensory deficit, i.e., problems with the timing of the transient and sustained visual systems during visual processing. The transient visual system response of poor readers was sluggish when compared to that of good readers and adults. It was hypothesized that the frosted overlays reduced the contrast of the light frequencies that inhibited the transient visual system. The transient visual system that is believed to be sluggish in some poor readers improved in function with the blurring of the visual arrays. In other words, for the poor readers, the temporal relationship between the transient and sustained visual systems was re-established with the use of the frosted clear overlays. This enabled the poor readers to achieve improved levels of visual search.

The blurring with use of the frosted overlays does not remediate the transient visual deficit but instead changes the temporal relationship between the transient and sustained system processing. Thus the normal timing of operation of the two systems was re-established and resulted in improved perceptual performance by the poor readers.

In 1988 Saint-John and White used computer technology to investigate the notion that colored overlays, rather than frosted clear overlays, improved the performance of children with reading disabilities. Two different types of tasks were used, a reading task and a reading-like letter identification task, similar to that used by Williams, Brannan and Lartigue (1987).

The purpose of the experiment was to demonstrate an immediate improvement using these two tasks with more rigorous controls for practice and placebo effects. The justification for using the letter identification task was that although tinted lenses may have had the immediate effect of clarifying the retinal image, there may not be an immediate change in reading performance. Thus this particular task was used to control for the practice effect because the letter to be identified changed with each trial. The placebo effect was addressed by choosing primary school children at random and by making sure that the subjects in no way believed that the use of colored overlays would help their reading.

The subjects included eleven, 6^{th} grade students who were specifically reading disabled (SRD) and 11 matched controls. The children with SRD had difficulty with reading despite being of average intelligence. Color selection of the overlays was achieved by having the subjects choose one of 6 colors through which a practice passage could be seen most clearly. These colored overlays were inserted into black eyeglass frames that were used for the remainder of the study.

The letter identification task was presented on a black and white VDU BBC Microcomputer. In this experiment no colored overlays were used to cover the monitor. Nor was the color of the monitor screen background changed. The chosen colored overlays were cut out and placed in black eyeglass rims. The three conditions included reading with a preferred colored overlay, a clear overlay or no overlay in the eyeglass rims.

The children were positioned with the head in a chinrest so that all subjects viewed the screen from the same distance and angle. The target letter to be identified was placed in the center of a three-letter combination, e.g. "X T X" with "T" being the target letter. The letter combination was presented at one of 15 possible locations across the horizontal meridian of the monitor screen.

The procedure included presenting a fixation point (an asterisk) in the center of the screen for one second. Next, the target letter combination was presented from randomly chosen letters at distances that varied from the left or right of the original fixation point. For each trial the subject identified the target letter by pressing the appropriate key on the computer keyboard. The subject could take as long as necessary to press the key. Each block of tests included 15 trials. In total there were 15 blocks with adequate rests between blocks. During the reading task, four, 11 line passages were selected from a textbook that was moderately easy to read for the age group. Pre-testing was performed to assure that there was a known baseline for each subject. During the post-test the same three overlays were placed in the eyeglass rims. These were with the preferred color overlay, a clear overlay and no overlay. The same passages were used in both the pre- and post-test and were presented in the same order. Apparently the authors were unconcerned about learning effects.

The recordings from all of the subjects were combined. As expected the group effect was highly significant indicating that the control group performed better than the group with SRD. On the letter identification test the results showed that the colored overlays did not affect the ability of the SRD group or the control group to identify and target letters. The results of the reading test showed that the post-tests were significantly different from the pre-tests. The authors disregarded this result believing it was due to a practice effect, for which they did not control.

The statistical analyses may be questioned because of the large standard deviations present for the group with SRD. This may suggest that combining the data for all subjects may not have been the best analysis as large standard deviations may indicate outliers that could confound the results. In other words, individual subjects within the group with SRD may have shown large improvement that would not be identified with the statistical analysis.

In addition, the letter identification was so controlled as to not approximate normal reading of a computer monitor. Perhaps a different reading paradigm on the computer monitor with pre- and post-tests may have given a more valid picture of how colored overlays might affect reading from a computer monitor.

Although there were many problems in the implementation and statistical analyses of this experiment, the comparison of reading from a computer monitor versus a textbook is an important one to consider since these are two of the primary reading modes in use today.

Williams, LeCluyse and Rock-Facheux (1992) combined the methods of the previous two experiments. They investigated the changes in academic performance when colored overlays and frosted clear overlays were placed over computer monitors and regular texts. The major purpose of this experiment was to look at the effects of colored overlays and the blurring effects of frosted clear overlays on visual processing and the effect of the overlays on the transient visual system.

The subjects were thirty-six, 8 to 12 year old students of average intelligence and with normal color vision and visual acuity. Eighteen of the students were reading at the appropriate grade level and 18 were diagnosed as having specific reading disabilities (SRD).

The methods included covering the monitor of an Apple IIGS computer with either a colored overlay or a frosted clear overlay. There were three conditions requiring different degrees of input from the transient visual processing system (Lovegrove, Martin & Slaghuis, 1986). The first condition presented one word at a time with each word being centered on the monitor. This condition demanded no eye movement and required the least processing by the transient visual system. During the second condition passages of text were presented one line at a time with the words painted from left to right in a moving fashion. The eye movements were guided by the presentation of the text and required more activation of the transient visual system than the first condition. In the third condition a passage of 200 words was painted simultaneously on the monitor, one line at a time. Reading the passage required free eye movement and put the greatest demands upon the transient visual system.

Each condition was presented with white letters on a black background or with the monitor covered with red, blue or frosted clear overlays. The white text on a black background is the reverse of the way that text is usually presented. Covering the monitor with red or blue colored overlays made the text appear colored. To determine if the effects were due to the actual text being colored, the passages also were presented as black text on monitors with blue, green or red backgrounds. Shades of light and dark gray backgrounds also were used to determine if decreased contrast, independent of color alone, would change performance. Comprehension was tested after every two paragraphs with the text being displayed on each monitor background color. Finally, comprehension and rate of reading were tested with the same colored and frosted clear overlays being placed over actual text instead of being presented on the computer monitor.

The results showed that those reading at grade level generally responded differently when compared to the subjects with SRD during the three conditions that required increasing demands upon the transient visual system. With the average readers in the no-eye movement condition, blurring of the text presented on the monitor improved performance. However, in the eye-movement condition, the average readers had a decrease in performance in both the color and blurred conditions. The improvement among the average readers in reading in the non-eye movement condition during the blurred condition was believed to occur because, under normal conditions, the transient visual system would not be activated in the non-eye movement condition. Thus there would be a lack of inhibition by the transient visual system causing a masking effect that would result in a greater lag of integration from one fixation to the next. It was hypothesized that blurring might act to decrease the masking effect thus making reading easier among the normal subjects. In the eye movement condition blurring and the blue color disrupted the pattern of transient/sustained interaction thus causing a decrease in performance among those reading at grade level.

The reverse trend occurred with the subjects with SRD in the eye-movement condition. Eighty percent showed improved performance when blue or frosted clear overlays were used during this condition that required the most transient visual system activation. The remaining 20% performed best with the white text or black text on white backgrounds. A small subgroup showed beneficial effects with red backgrounds and overlays.

The results also showed that approximately 70% of subjects with SRD had transient visual system processing deficits. This was believed because, without any overlays, these subjects performed most poorly in the trials that required the most transient visual system processing, the free eye movement condition. This suggested that the reading ability of the children with SRD deteriorated as more demands were placed upon the transient visual system.

Reading comprehension when compared on different colored monitor backgrounds also was different for the two subject groups. Reading comprehension and reading rate with average readers improved significantly with the blue background only. The subjects with SRD showed significant improvement in comprehension and in reading rate when the computer monitors had blue backgrounds or light gray backgrounds.

The authors suggested that the blue and blurred texts might create enough of a separation between transient visual system and sustained visual system responses to establish a normal pattern of transient/sustained interaction in the subjects with SRD. The simple reduction of stimulus contrast with the use of a light gray background on the computer monitor was independent of color, yet it appeared to mitigate the transient visual system problem sufficiently to improve performance in the subjects with SRD.

The red backgrounds generally were detrimental for both groups. This was interpreted as an indication that the red stimulus slowed transient visual system processing causing exacerbation of visual deficits, especially in the subjects with SRD. Conversely, the red backgrounds were believed to stimulate the transient system processing deficits in the normal subjects thus disrupting the normal pattern of transient/sustained interactions. Finally, the results from using overlays on actual books were comparable with those of the computer monitor presentations.

The previously cited studies investigated the effects that overlays, clear, frosted or colored, had on symptoms in those with transient visual system deficits. It was assumed that if those with reading related problems were helped with overlays, they had transient visual system deficits. It had previously been shown that average readers had improved performance when blue colored overlays are used (Williams, Lecluyse & Rock-Faucheux, 1992). This suggested that some average readers had weak transient visual systems, even though they were not delayed in reading.

To examine this possibility, Croyle (1998) chose subjects with and without transient visual system deficits in children who were both good and poor readers. The subjects included 4 students who were reading disabled transient deficient (RdTd), 4 who were reading normal transient deficient (RnTd), 4 who were reading disabled transient normal (RdTn) and 4 who were reading normal transient normal (RnTn). The ages of the subjects ranged from 8.10 years to 9.6 years. The reading levels were determined using the Neale Analysis of Reading Ability-Revised, (Neale, 1988). Transient system visual processing ability was tested using the Irlen Institute's, *Scotopic Sensitivity Syndrome Screening Manual* (Irlen, 1991). The effects of colored overlays on reading rate were examined while controlling for accuracy and comprehension.

The experiment consisted of presenting reading material on a Macintosh color monitor of an Apple Macintosh IIvx computer. The readings were 6 paragraph like structures made of 15 basic words on 10 lines from the test material of the New Century Schoolbook. Each paragraph contained 150 words, in random order. Pre-tests showed that subjects were able to read all of the random words prior to the experiment.

The students were seated comfortably in front of the computer. They were at eye level with the computer at a viewing distance of 30 cm. The paragraphs were presented in 9-point black text with typical spacing of the letters within and between words. The color contrast presented on the background of the monitor were hues of blue, red and gray at high and low contrast intensity levels. Each student read the paragraphs orally while the researcher recorded rate of reading in seconds and the accuracy in numbers of words pronounced correctly within a three-second period.

The results showed that there was a significant three-way interaction between visual processing, color and intensity level on reading rate and accuracy for all subjects. The blue background affected the transient deficient (Td) and transient normal (Tn) groups differently depending upon the intensity level. With high intensity levels the reading rate improved most significantly with the blue background for the Td group. With low intensity levels the reading rate for the Td group improved most significantly with the gray background. Reading accuracy improved most at low intensity rather than at high intensity for both groups. The Td and Tn subjects processed differently with a red background depending upon the intensity level being high or low.

Students with normal transient visual system processing had the same results with high intensity levels with both gray and blue backgrounds. However, with red backgrounds and high intensity the reading rates decreased. Therefore, red backgrounds with high intensity may be assumed to inhibit transient visual system processing with Tn subjects.

For students with deficient transient visual system processing, the red and gray backgrounds results were similar under the high intensity level condition. Surprisingly, the blue background with high intensity caused a slight decrease in performance. It was hypothesized that the difference in the type of display, computer monitor or overlays over text, may have produced a different effect on the transient visual system. The computer monitor does not reduce the contrast in the same manner as the overlays placed over text.

Overall, the results showed that on computer monitors, performance may change depending upon the presentation with high or low intensity and whether the stimulus background color is blue, red, or gray. At low intensity levels, the Td students showed significant improvement in performance with the blue background. However, with red and gray backgrounds under high intensity levels, these same subjects read faster.

It is not possible to manipulate the intensity of contrast of color stimuli with text to the same extent that intensity of contrast can be manipulated on a computer monitor. These results suggest that different conditions may be required for successful reading between text and computer monitors.

The above studies illustrate that reading performance can be improved with the use of colored overlays and by adjusting the background colors on computer monitors. The remaining question is if the use of the colored computer monitor presentation would be as effective or more effective as a learning tool than overlays over actual texts for preschool children with disabilities. This question will not be examined in this study.

Summary

The use of colored overlays to improve reading performance remains controversial. However, Robinson and Foreman (1999) reviewed 17 studies in which colored overlays were used during reading tasks. According to these authors sixteen of the studies showed improved reading skills with the use of colored overlays while one study showed no improvement.

Effective reading skills lay the groundwork for future success in academic performance. Only two studies have been identified that include children of preschool age. The studies occurring in mainstream classrooms may or may not include children with disabilities. This study will add to the literature by examining the usefulness of colored overlays to improve symbol identification in preschool children with disabilities and will introduce an easy method of using colored overlays for classroom use.

CHAPTER 3

METHODS AND PROCEDURES

Subjects

The participants in this study were students at the Lynn Bennett Early Childhood Education Center (LBECEC) who were 3 to 5 years old. Informed consent forms were sent to 92 parents. Thirty-three of the informed consent forms were signed and returned by the parents. Each child was given a number and was identified throughout the study only by the number.

From this pool of 33 students three groups were formed according to age, screening scores and availability throughout the 5 week period during the summer when data collection occurred. Each group included 6 children, three children with disabilities who had a current Individual Education Program (IEP) and three children without disabilities. The total number of participants was limited to 18 children because only 11 of the students with parental consent had current IEPs. Thus, 9 of the 11 children with IEPs were included in the study. Each group included both girls and boys spanning the age ranges from 3 to 5 years.

Demographics

The ages of the children in each group were matched as closely as possible. The original formation of each group included one 3 year old, one 4 year old and one 5 year old with a disability and one 3 year old, one 4 year old and one 5 year old without a disability. The age configuration of Group I differed from Groups II and III because one 3 year old with a disability was unable to perform the Pretest task. This child was replaced with a 5 year old with a disability. One of the 3 year old children without a disability in Group I was categorized as a 3 year old but was only a few days away from the fourth birthday. Thus the age configuration of Group I was one 4 year old and two 5 year olds with disabilities and two 3 year olds, and one 5 year old without disabilities. Groups II and III each included one 3 year old, one 4 year old and one 5 year old with a disability, and one 3 year old, one 4 year old and one 5 year old without a disability. Subjects 9 and 12 were twins. Subject 9 was a female with a disability. Subject 12 was a female without a disability. Table 1 gives the demographics of the three groups.

Setting and Materials

All testing occurred in a room connecting two classrooms that generally was used for individualized activities with students. Because the tester was unfamiliar to the children, they were escorted to the room by a teacher or an aide. With the 3 year old children the aide usually remained in a far corner of the room during testing. All of the children to be tested sat in the same chair and at the same circular wood table. The dimensions of the table were 25-1/2 inches in diameter and 20 inches in height.

TABLE 1 PARTICIPANT DEMOGRAPHICS

Subject #	Date of Birth	Chronological Age	Gender	IEP
GROUP I				
1	4/26/01	4.1 years	M	Yes****
2	1/16/00	5.4 years	M	Yes****
3	10/16/99	5.7 years	M	Yes*
4	10/19/01	3.7 years	M	No
5	09/29/01	3.8 years	F	No
6	1/07/00	5.4 years	F	No
GROUP II				
Subject #	Date of Birth	Chronological Age	Gender	IEP
7	12/15/01	3.5 years	M	Yes*
8	10/06/00	4.7 years	F	Yes**
9	02/25/00	5.3 years	F	Yes**
10	12/06/01	3.5 years	M	No
11	01/08/01	4.4 years	F	No
12	02/25/00	5.3 years	F	No
GROUP III				
Subject #	Date of Birth	Chronological Age	Gender	IEP
13	01/10/02	3.4 years	F	Yes*
14	05/14/01	4.0 years	M	Yes****
15	02/05/00	5.3 years	F	Yes***
16	02/27/02	3.3 years	M	No
17	02/02/01	4.3 years	F	No
18	11/06/99	5.6 years	M	No

*Developmental delay **Orthopedic impairment ***Hearing impairment ****Autism

The LEA Playing Cards, developed by Lea Hyvärinen, M.D., (Hyvärinen, L., 1980), were used during the screening to assess the ability to point to a symbol. One large white card measuring 7” x 7” was imprinted with four black symbols (a circle, a house, an apple and a square). Four smaller cards measuring 3.5” x

3.5" each were imprinted with one of the four symbols. When the child was shown the symbol on the smaller card the task was to point to the same symbol on the larger card.

To screen for the preferred color overlay the Cerium Colour Overlays (Cerium Visual Technologies, Ltd., Kent, England) were used. Three identical white cards measuring 3.5" x 3.5" were imprinted with a black "X". The symbol of the "X" was 2 inches in height and 1-1/4 inches in width. These cards were individually covered with two colored overlays and one clear overlay during the Screening Phase. The colors of the 13 overlays were rose, purple, aqua, apple (lime green), orange, neutral (gray), yellow, leaf (mint green), blue, magenta, turquoise, lilac and clear.

During the Practice Session, the Pretest Phase and the Intervention Phase the LEA Near Vision Test, also developed by Lea Hyvärinen, M.D., (Hyvärinen, L., 1980), was used. This Test card consists of black symbols randomly placed on a white card measuring 10-1/4" x 8-1/4". The symbols were the same as those on the LEA Playing Cards, a circle, a house, an apple, and a square. There were 17 rows of symbols with 5 symbols in each row. The symbols were large at the top of the card and diminished in size going from top to bottom, similar to the standard Snellen test of visual acuity used in doctors' offices and for driving tests. For this study the first 9 rows of the LEA Near Vision Test were exposed for identification. A frame was made of white paper to limit the choices to the first 9 rows of symbols and to allow for easy insertion and removal of the overlays. Thus the child viewed the first 9 rows of symbols with 5 symbols in each row.

The largest symbols at the top of the card measured 1-4/10 cm. square. The symbols became progressively smaller with the symbols in the last line measuring 2/10 cm. square.

Screening Phase

All 33 children with signed informed consent forms were screened to determine first, if the participants could identify symbols by pointing and second, what the preferred color of overlay was for each child. The procedure entailed placing the large LEA Playing Card with printed black symbols, measuring 7" x 7" on the table in front of the seated child. The smaller LEA Playing Card, measuring 3.5" x 3.5" and imprinted with the circle was shown to the child. The instruction was given to point to the matching symbol on the larger card that was contained on the smaller card. When the child had pointed to the circle on the 7" x 7" card, the 3.5" x 3.5" card was turned over and the next symbol, the house, was shown to the child. The child was asked to match all four symbols (circle, house, apple and square) in this manner. The largest symbols of the LEA Playing Cards were used during the screening for ease of identification.

To determine the preferred color overlay for each child, three identical white cards containing a black "X" and measuring 3.5" x 3.5" were placed side by side on the table, 3-1/2 inches apart. Two of the cards were covered with a colored overlay and one card was covered with a clear overlay. The position of the clear overlay was randomized. This was done to assure that a choice would be made on the basis of a preferred color rather than the position of the clear overlay in the row.

When each card was covered by an overlay, the instruction was “Pick one”. The tester looked at the child while giving the instruction so that no indication for choice would be given by the tester’s gaze. The chosen overlay was placed in a separate pile from the non chosen overlays. If the clear overlay was chosen then both colored overlays were replaced with different colored overlays. For example, suppose that the overlay covering the first “X” was blue, the second “X” was covered by the clear overlay, and the third “X” was covered by a yellow overlay. If the child chose the blue overlay, the yellow overlay was put in the “non chosen” pile and the blue overlay was put in the “chosen” pile. Next, to randomize the position of the clear overlay, the first “X” might be covered by the clear overlay, the second “X” would be covered by the magenta overlay and the third “X” would be covered by the mint green overlay. If the child chose the mint green overlay it would be placed in the “chosen” pile while the magenta overlay would be placed in the “non-chosen” pile.

When the child had completed choosing from the 12 overlays plus the clear overlay the procedure was repeated with the overlays only from the “chosen” pile. The procedure was repeated until a single colored overlay or the clear overlay remained.

Practice Session

Prior to the Pretest Phase each child practiced the procedure required for the Pretest and Intervention phases. The LEA Near Vision Test card, without an overlay, was placed on the table in front of the seated child. The symbol of the circle from the LEA Playing Cards (3.5" x 3.5") was shown to the child. The instruction given was to point to all of the circles on the LEA Near Vision Test card.

The experimenter initially guided the child to start looking at the line at the top of the Test card and move toward the bottom of the card while looking for the symbol of the circle. It was assumed that the instruction was understood when the child successfully pointed to the target symbol in the top row then repeated the procedure in the successive rows. Even if some of the symbols were not identified correctly or were missed, it was assumed that the instruction was understood if the child started at the top of the Test card and moved toward the bottom of the card. Each child was given as much time as necessary to assure that the procedure was understood.

Pretest Phase

The Pretest Phase began not less than one week following the Screening Phase. To determine a baseline, each child was administered identical tests again using the LEA Playing Cards and the LEA Near Vision Test. Three tests were administered using first a clear overlay, second the preferred color overlay and third the non-preferred randomly chosen overlay. A different symbol was used for testing with each overlay. The same three symbols were used with each child for each baseline test. The symbols were presented in the same order. The tester silently counted and recorded the correct number of choices.

For example, the LEA Near Vision Test, without being covered by an overlay, was placed on the table in front of the seated child. The small LEA Playing Card (3.5" x 3.5") with the symbol of the circle was shown to the child.

The child was instructed to point to all of the circles on the Test card. This was used to review the procedure if necessary. The LEA Near Vision Test then was covered with a clear overlay. The individual symbol of the house was shown to the child who was instructed to point to all of the symbols of the house on the Test card. Next, the Test card was covered with the preferred color overlay that had been chosen by the child. The LEA Playing Card with the symbol of the apple was shown to the child. The instruction was given to point to all of the symbols of the apple on the Test card. Finally, the Test card was covered with one of the colored overlays that had not been chosen as the preferred overlay by the child. This non-preferred colored overlay was randomly chosen by the tester. The individual symbol of the square was shown to the child and the same instruction was given. The type of overlay (clear, preferred and non-preferred) and the symbols (house, apple and square) were presented in the same order for each child.

Intervention Phase

The three groups previously formed were used for the Intervention Phase. The first group (Group I) was the comparison group that identified symbols on the LEA Near Vision Test that was covered with a clear overlay. The second group (Group II) identified symbols on the LEA Near Vision Test that was covered with each child's choice of preferred color overlay. The third group (Group III) identified the symbols on the Test card that was covered with the same non-preferred color overlay that was assigned to those in Group III had during the Pretest.

The procedure once again involved placing the LEA Near Vision Test card in front of the seated child. The LEA Near Vision Test was covered with the overlay as determined by the Group in which the child was placed. For the 6 children in Group I the Test was covered with the clear overlay. Those in Group II identified the symbols with the Test covered with the child's preferred color overlay. Group III identified the symbols with the Test covered with the non-preferred color overlay.

The black symbols on the 3.5" x 3.5" white cards were presented in the same order as occurred during the Pretest. The child first was shown the circle and instructed to point to all of the circles on the Test card. Once again this was used as a review of the procedure if the child did not start pointing to the symbols on the first line at the top of the card. Then the individual LEA Playing Cards were presented in the order of house, apple and square with the same instruction to point to the all of the respective symbols on the Test card.

Post-test

A post-test was administered using the Intervention procedure approximately 2-1/2 months following the Intervention Phase. This delay was caused because of scheduling problems and school vacations. Thus, when the Fall semester resumed only 10 students were administered the Posttest. The remaining 8 children had graduated or moved to other areas.

CHAPTER 4

RESULTS

The purpose of this study was to examine the impact of colored overlays on the accuracy of preschool children in identifying target symbols, to examine whether accuracy was related to disability status, to examine the possibility of an interaction between the impact of the overlays and the disability status, and to find if there was a particular color that was most often chosen as the preferred color. This purpose was accomplished through testing the following hypotheses:

1. There will be no significant difference in accuracy scores between the Pretest and Intervention phases of the study.
2. There will be no significant difference in accuracy scores in the Intervention phase between children with and without identified disabilities.
3. There will be no significant difference in accuracy scores in the Intervention phase between children using clear, preferred color, or randomly assigned colored overlays.
4. There will be no significant interaction in accuracy scores in the Intervention phase between disability and overlay conditions.
5. There will be no significant choice of a single color as a preferred color

Hypothesis 1

Comparing Pretest and Intervention Accuracy Scores

The first hypothesis was tested using a one-way Analysis of Variance (ANOVA) with repeated measures. The difference between Pretest and Intervention phase accuracy scores was not statistically significant, $F(1,17) = 3.262$, $p = .089$. Mean accuracy scores for the Pretest and Intervention phases were 6.93 and 7.41, respectively. While there was evident improvement in accuracy between the Pretest and Intervention phases, the extent of difference was at the level suggesting the likelihood of only random variation. Hypothesis 1 was not rejected.

Hypothesis 2

Comparing Intervention Accuracy Scores of Children With and Without Disabilities

Hypothesis 2 was tested with a one-way ANOVA. Differences in performance between children with and without disabilities were not statistically significant, $F(1,16) = .004$, $p = .951$. The mean score of the children with disabilities was slightly higher than the mean score of the children without disabilities, but the difference was negligible. Mean scores for the two groups were 7.43 and 7.38 respectively.

Although Hypothesis 1 was not rejected, the difference between Pretest and Intervention scores approached the level required for identification of statistical significance. To explore the possibility that differences in Pretest accuracy scores may have masked differences in Intervention phase accuracy scores between children with and without disabilities, a second test of this hypothesis was conducted using analysis of covariance (ANCOVA).

Pretest accuracy scores were used in the ANCOVA as a covariate to adjust the intervention accuracy scores for differences in Pretest performance. The ANCOVA result also was not statistically significant, $F(1,15) = .007$, $p = .932$. Hypothesis 2 was not rejected.

Hypothesis 3

Comparing Intervention Accuracy Scores of Children Using Clear, Preferred or Non-Preferred, Randomly Assigned Colored Overlays

Hypothesis 3 also was tested with a one-way ANOVA. Differences in the Intervention accuracy scores between the children using clear overlays, preferred or non-preferred, randomly assigned colored overlays were not statistically significant $F(2,15) = .081$, $p = .923$. The group using the clear overlays had the highest mean accuracy scores (7.617), followed by the mean accuracy scores of those in the preferred color overlay group (7.433), and finally, the mean accuracy scores of those in the non-preferred, randomly assigned color overlay group (7.167).

As with Hypothesis 2, a second test was conducted using an ANCOVA to explore the possibility that differences in the Pretest accuracy scores may have masked differences in the Intervention phase accuracy scores between the three groups.

The Pretest accuracy scores were used as a covariate in this ANCOVA. The results were not statistically significant $F(2,14) = .678$, $p = .534$. Although Hypothesis 3 was not rejected, there was a change in the p value when using the ANOVA from $p = .923$ to $p = .534$ when using the ANCOVA. However, these results did not suggest that this was anything other than a chance occurrence. Hypothesis 3 was not rejected.

Figure 1 shows the Intervention accuracy scores of the three groups as related to the disability status.

Hypothesis 4

Comparing Interactions of Accuracy Scores Between Disability and Overlay Conditions in the Intervention Phase

Hypothesis 4 was tested using a two-way ANOVA. Interactions between the three groups (clear overlays, preferred color overlays and non-preferred, randomly assigned colored overlays) and those with and without disabilities were analyzed. The results of this interaction were not statistically significant $F(2,12) = 1.351$, $p = .296$.

Although not reaching statistical significance, there was an interaction between the two types of overlays (clear vs. preferred) and the disability factor. This is shown in Figure 2. When the children without a disability used the clear overlay there was an increase in the Intervention accuracy scores with respect to the Intervention accuracy scores when they used the preferred color overlay, while the children with disabilities showed an increase in Intervention accuracy scores when using the preferred color with respect to the Intervention accuracy scores when using the clear overlay.

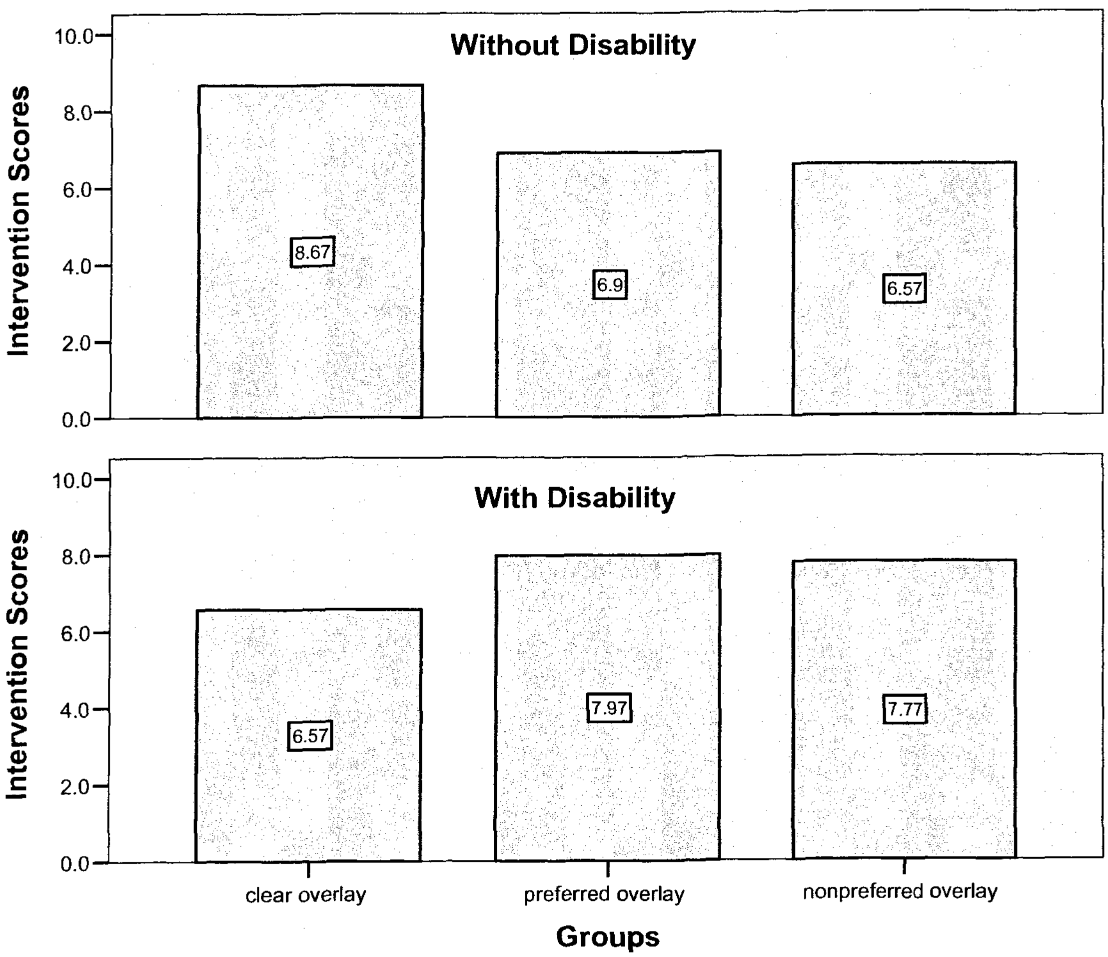


Figure 1. Comparison of means of 3 groups with and without disabilities during Intervention phase.

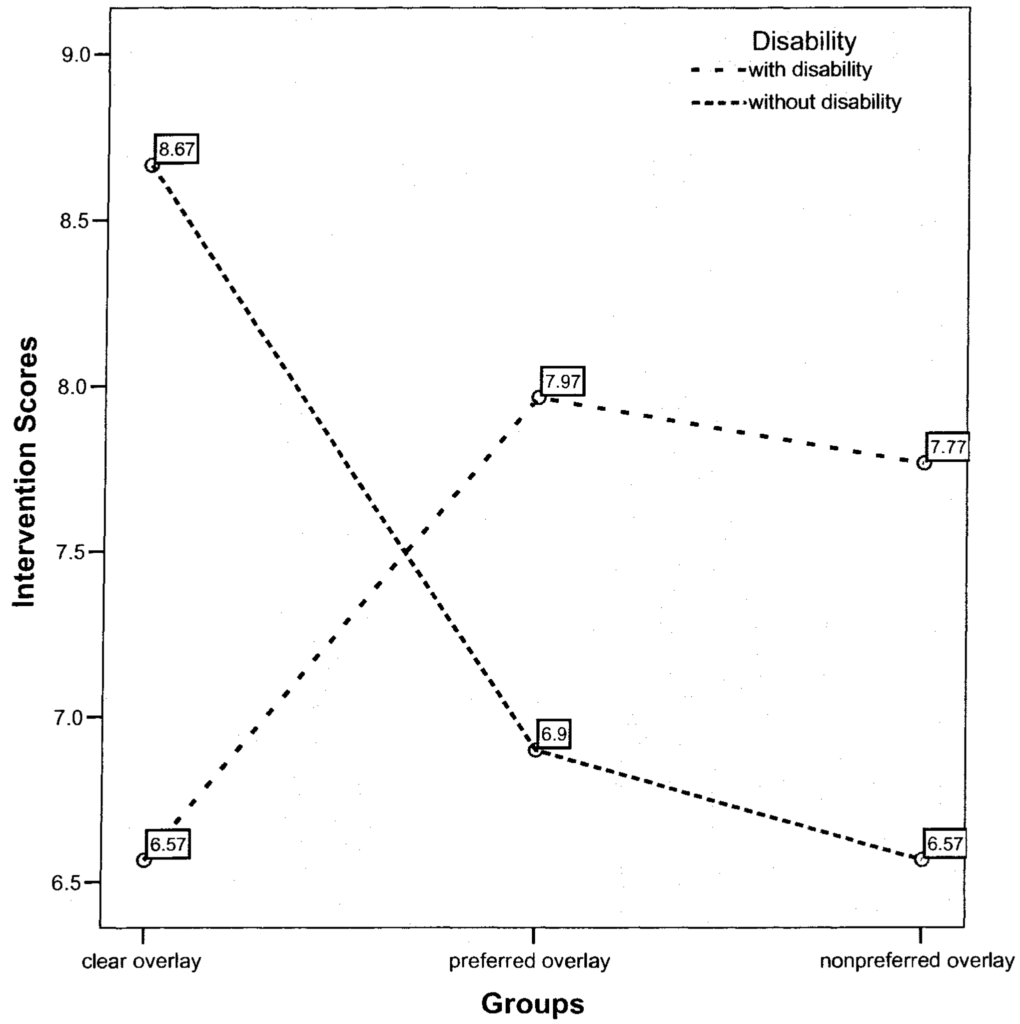


Figure 2. Interactions between the 3 groups and disability scores

To control for the Pretest accuracy scores as in Hypotheses 2 and 3, an ANCOVA analysis was performed using the Pretest accuracy scores as a covariate. Although the *p* value was reduced $F(2,11) = 1.794$, $p = .212$, it still did not reach statistical significance. Hypothesis 4 was not rejected.

Hypothesis 5

Comparing Preferred Color Choices Between Disability and Overlay Conditions

Hypothesis 5 was tested using a two-way ANOVA between the three groups and the disability factors. Differences in the preferred color choices between the groups were not statistically significant $F(2,12) = 1.688$, $p = .226$. Nor were the preferred color choices between those with and without disabilities statistically significant $F(1,12) = .043$, $p = .839$.

Table 2 shows the preferred color chosen according to age, disability factor and gender.

The most frequently chosen preferred color was neutral (gray) and was chosen by 22% of the children. Four males chose neutral (gray), 3 with disabilities and one without a disability. Following the most frequently chosen preferred color, 3 children chose either magenta or orange. All of the children choosing magenta or orange were female. Two children chose either rose, apple (lime green) or the clear overlay. The children choosing either the clear or the lime green overlays were male. The 2 children choosing the rose overlay were female. One male child chose leaf (mint green) and one female child chose turquoise.

Of the 12 colors used from the Cerium Colour Overlays, 7 colors were chosen as the preferred color. Five colors were never chosen as the preferred color. These colors were yellow, purple, aqua, lilac and blue. Hypothesis 5 was not rejected.

TABLE 2 PREFERRED COLORS ACCORING TO AGE, DISABILITY, NON-DISABILITY AND GENDER

Preferred Color	Subject #	Age (yrs.)	Gender	IEP
Neutral (gray)	7	3.5	Male	Yes*
Neutral (gray)	14	4.3	Male	Yes****
Neutral (gray)	3	5.7	Male	Yes*
Neutral (gray)	18	5.6	Male	No
Magenta	17	4.3	Female	No
Magenta	6	5.4	Female	No
Magenta	15	5.3	Female	Yes***
Orange	13	3.4	Female	Yes*
Orange	11	4.4	Female	No
Orange	12	5.3	Female	No
Clear	16	3.3	Male	No
Clear	2	5.4	Male	Yes****
Apple (lime green)	4	3.7	Male	No
Apple (lime green)	10	3.5	Male	No
Rose	5	3.8	Female	No
Rose	8	4.7	Female	Yes**
Leaf (mint green)	1	4.1	Male	Yes****
Turquoise	9	5.3	Female	Yes**

*Developmental delay **Orthopedic impairment ***Hearing impairment****Autism

Interrater Reliability

An interrater reliability check was performed twice near the end of data collection with an accuracy score of 97%.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The first purpose of this study was to assess the difference between Pretest and Intervention accuracy scores in the identification of target symbols while using three different types of overlays, clear overlays, preferred color overlays and non-preferred, randomly chosen overlays. The second purpose was to assess the difference between Pretest and Intervention accuracy scores in the identification of target symbols among children with and without disabilities during the three different overlay conditions. The third purpose was to find the preferred color for each child and determine if there was consistency in identifying a particular color as the preferred color.

Although not included in the research questions, Posttest data were collected from ten children in the original subject group. These data were collected approximately 2-1/2 months following the initial data collection and were not included in this analysis.

General Results

The main findings for the Intervention phase were that there was no statistically significant difference in the number of accurate symbol identifications between children with and without disabilities when using clear overlays, preferred color overlays or non-preferred randomly chosen color overlays.

Although not reaching the level of statistical significance, there was a trend during the Intervention phase for the children with disabilities to achieve slightly higher accuracy scores in the Group using the preferred color overlays. Finally, there was no single color that was predominantly chosen as a preferred color.

Comparison of Pretest and Intervention Accuracy Scores

The repeated measures ANOVA did approach statistical significance [$F(1,17) = 3.262$, $p = .089$]. Not reaching the $p < .05$ significance level may have occurred because of the small number of subjects. It is possible that with a larger subject pool these results may reach the statistical significance level. To examine this finding further and to assess what other factors contributed to the Intervention accuracy scores, the group accuracy scores and the disability accuracy scores were evaluated individually.

Comparison of Intervention Accuracy Scores and the Disability Factor

The Intervention accuracy scores of those with and without disabilities was not statistically significant [$F(1,16) = .004$, $p = .951$]. There was only a slight difference between the means of those was with disabilities (7.43) and those without disabilities (7.38). These results suggest that the contribution of the disability factor to the overall Intervention accuracy scores was minimal. However, there was a trend of the children with disabilities to correctly identify slightly more symbols than those without disabilities.

A second test was performed with the disability factor while controlling for the Pretest scores. This analysis changed the significance level only slightly [$F(1,15) = .007$, $p = .932$] again confirming that the disability factor did not have a major impact on the overall Intervention accuracy scores.

Comparison of Intervention Accuracy Scores and the Group Factor

The Intervention accuracy scores of the three overlay groups (clear, preferred and non-preferred randomly chosen) was similar to that of the disability factor [$F(2,15) = .081$, $p = .923$]. These results suggested that the group factor alone did not contribute significantly to the overall Intervention accuracy scores. However, there was a decreasing trend from the group using the clear overlays and the groups using colored overlays. The group using the clear overlay had the highest accuracy scores (7.617), followed by the group using the preferred color overlays (7.433) and the non-preferred randomly chosen color overlays (7.167). This suggested that colored overlays when contrasted with clear overlays do not significantly improve the Intervention accuracy scores. Within the colored overlay groups, however, the group using the preferred color overlay identified more symbols correctly than those in the group using the non-preferred color overlays.

Controlling for the Pretest scores using an ANCOVA analysis resulted in a change in the results [$F(2,14) = .678$, $p = .534$]. When compared to the results without controlling for the Pretest scores [$F(2,15) = .081$, $p = .923$], this may be considered to be a substantial change in the p value. This result suggested that the Intervention group accuracy scores might come closer to statistical significance with a larger number of subjects or that analysis of other factors, such as age or gender, may contribute to the results.

Interactions Between Group Factor and Disability Factor

The interaction accuracy scores between the 3 groups and the disability factor were not statistically significant ($F(2,12) = 1.351$, $p = .296$)]. The mean Intervention accuracy scores for the children without a disability were higher for the group using clear overlays (8.67) than the group using the preferred color overlays (6.9) or the non-preferred color overlays (6.57). By contrast, the mean Intervention accuracy scores for the children with disabilities were lowest with the group using the clear overlays (6.57) and were highest for the group using the preferred color overlays (7.97). The mean Intervention accuracy scores for the children with disabilities in the group using the non-preferred color overlays were similar to the group using the preferred color overlay (7.77).

The trend of the children with disabilities having higher Intervention accuracy scores when using the preferred color overlays was predicted in Hypothesis 4. However, this trend without reaching the level of statistical significance is likely to be due to random variation only.

A second interaction was calculated using the Pretest as a covariate. This analysis resulted in a negligible change in the significance level [$F(2,11) = 1.794$, $p = .212$] and not reaching the statistical significance level of $p < .05$.

Preferred Color

Overall, this study found that there was no single color that was chosen as the preferred color by the majority of children in this study. A one-way ANOVA between the preferred color choices and the groups factor was not statistically significant [$F(2,12) = 1.688$, $p = .226$]. Neither was the one-way ANOVA between the preferred color choices and the disability factor statistically significant [$F(1,12) = .043$, $p = .839$]. This finding is consistent with the existing research. Jeanes, et al., (1997), suggested that because choosing preferred colors for overlays is so highly individual that using only the basic colors of red, blue and green for overlays may not achieve good results.

Neutral gray was the single most frequently chosen color overlay among the participants of the present study (22%). Three of the four participants choosing gray as the preferred color were children with disabilities. This suggested that it may not be the color of the overlay that is important in identifying symbols, but rather the overlay that decreases the contrast between the symbol and the background that is more important. This also was suggested in a study by Williams, LeCluyse and Rock-Facheux (1992) who found that a reduction of contrast with the use of a light gray background on a computer monitor improved performance in the subjects with specific reading delays.

Conclusions

Although using colored overlays to improve academic performance remains controversial, there have been positive results with the use of colored overlays among children with known reading delays (Solman, Cho & Dain, 1991; Christenson, Griffin & Taylor, 2001). Wilkins, et al., (1991) suggested that 20% of children with reading delays showed symptoms of transient visual system disorder (TVSD), an impairment of the visual cortex. TVSD does not impair visual acuity but may diminish the ability to perform complex visual tasks such as reading. When the preferred color overlay was placed over text material, 70% of these children with TVSD improved their reading skills.

In the present study testing for reading delays was precluded because the subjects only were able to identify symbols and letters. None of the subjects were able to read words or sentences. In addition, no testing for TVSD was attempted because of the generally limited attention span among 3-5 year olds. The procedure for testing for TVSD involves covering a sheet of text with two different colored overlays placed side by side. The child is then asked to choose which side that looks more clear. By a process of elimination the overlay that clarified the text the most is chosen.

No such restrictions were placed on the children's choice of overlay during the screening. They were simply asked to choose an overlay covering one of the cards with the "X". Thus, the procedure was kept simple and only required concentration on the task for two to three minutes, well within the capabilities of these 3 to 5 year old children. The lack of statistical significance may be due to none of the participants having TVSD.

Other researchers have concluded that only certain colors of overlays facilitate reading performance. For example, Iovino, Fletcher, Breitmeyer and

Foorman (1998) suggested that text covered with a blue overlay facilitated reading. This was not the case for identifying symbols in the present study.

King-Smith and Carden (1976) suggested that the interaction of the three types of cones that were present on the retina, red, green and blue, impacted differently on vision. The green and red sensitive cones were said to have inhibitory interactions on vision while stimulation of the blue sensitive cones was not inhibitory.

While there is no way to determine how stimulation of the color cones on the retina with the use of overlays affected vision in this study, it can be noted that the blue overlay was never chosen as the preferred color. However the green overlays were chosen by 4 out of the 18 children (22%) and the overlays in the red range were chosen by 5 out of the 18 children (28%).

A question may be raised with regards to the simplification of the screening procedure leading to the children choosing their favorite color rather than the color that clarified the symbol. A possible reason for the statistically non-significant results may be that the favorite color was indicated as the preferred color rather than color that made it easier to identify the test symbols. However, prior to testing the children were casually asked "What's your favorite color?" Eight of the 18 subjects did not have a favorite color. Of the remaining 10 children who specified a favorite color, 6 chose a preferred color similar to their favorite color and 4 chose a preferred color other than their favorite color. This suggests that the children did not necessarily indicate a preferred color that also was their favorite color.

Summary

These results showed no statistically significant results between the Pretest and Intervention accuracy scores. However, the results of the one-way ANOVA with repeated measures between the means of the Pretest accuracy scores and the means of the Intervention accuracy scores did approach statistical significance suggesting that a larger subject number might improve the findings. Results of the interaction analysis between the group and disability factors were not statistically significant. There was a trend in which children with disabilities achieved higher Intervention mean accuracy scores when using preferred color overlays as predicted in Hypothesis 4. However, this trend was not statistically significant which suggested that the results were only random variation. Finally, in this study there was no color that was chosen as the preferred color by the majority of children.

Recommendations for Future Studies

1) Replicate this study with a larger number of pre-school age subjects both with and without disabilities..
2) Since previous research suggested that those with transient visual system deficit (TVSD) improve the most with the use of colored overlays, do a more thorough screening of pre-school age subjects to determine if TVSD is present in pre-school age children who do not yet read.
3) Study the impact of the use of colored overlay over computer monitors as compared to changing the color and intensity level of the background on

computer monitors and the impact on improving performance of tasks on computers in pre-school age children.

4) Compare and contrast the effectiveness of using colored overlays over text or symbols and computer monitors for improving performance in pre-school age children.
5) Longevity study to investigate the change in reading related skills with the consistent use of preferred color overlays in pre-school age children .
6) Investigate the effectiveness of the use of colored overlays for those with specific disabilities such as Down syndrome or mental retardation.

APPENDIX I

PARENT PERMISSION LETTER

Lynn Bennett Early Childhood Education Center

INFORMED CONSENT

General Information
I am Edith Naas, the principal investigator on a research project titled: Colored Overlays and Symbol Identification in Pre-school Children with Disabilities. This study is being conducted at the UNLV Preschool and I am inviting your child to participate.

Purpose of the Study
The purpose of the study is to find out if pre-school children will be able to identify symbols more accurately when they look through transparent colored plastic sheets (overlays). Looking at a symbol and then finding the same symbol among a group of symbols on a page is a basic skill required for learning. We hope that the information gained from this study may help us to identify pre-school children, with or without disabilities, who will improve in this skill when they look at a page of symbols or letters that is covered with a colored overlay.

Procedure
If you allow your child to participate in this study, you will be asked to sign this form for consent to allow me to screen your child on being able to point to matching symbols and to pick their favorite color. Following the screening your child may be asked to participate in more testing that will involve pointing to individual symbols that are on a card covered with different colored overlays. The screening and any additional testing will occur individually in a room separated from the general classroom. The researcher will ask the classroom teacher if it is an appropriate time to screen or test the child. If the time is agreeable with the teacher she will approach the child or instruct the child to go with the researcher for testing or screening. Each test session will take approximately 10 minutes and will be spread out over a period of three weeks. There will be a total of four testing sessions. These will include a screening, a practice session to make sure that your child understands what to do, the intervention testing and a post-test that will be given approximately two weeks later. The total time for all testing will be about 40 minutes. The only person interacting with your child will be myself, the principal investigator. There will be a secondary observer present at least 25% of the time to assure consistency of procedures.

Benefits of Participation
By participating in this study your child will be contributing to the understanding of a simple method that can be used in the classroom to help pre-school children with their learning skills. At the completion of this study you will have the opportunity to discuss the findings regarding your child's performance when using colored overlays. There may or may not be a direct benefit for your child.

Colored Overlays and Symbol Identification in Pre-school Children with Disabilities
INFORMED CONSENT (continued)

Risks of Participation
There are minimal risks involved in this study. Your child will be invited to leave the classroom only under the guidance of the classroom teacher to ensure that the testing periods will not cause a disruption in the daily classroom routine. Under no circumstances will your child be asked to leave the classroom without the approval of the classroom teacher.

Confidentiality
Your child will be identified by a number and will not be identified by name anywhere on our records. No reference will be made or recorded that could link your child to this study. All information gathered in this study will be kept completely confidential. All records will be stored in a locked facility, under my control, for at least three years after completion of the study. After the storage time the information will be destroyed.

Contact Information
If you have any questions about the study or if you believe your child may have experienced harmful effects as a result of participation in this study, please contact me, **Edith Naas at (775) 224-3884 or my faculty advisor, Dr. John** Filler, at (702) 895-1105.

For questions regarding the rights of research subjects, you may contact the UNLV Office for the Protection of Research Subjects at (702) 895-2794.

Voluntary Participation
Participation in this study is voluntary. Your child may refuse to participate at any time. If your child wishes to withdraw there will be no repercussions or prejudice in their relations with their teachers or the UNLV Preschool. You and your child are encouraged to ask questions about this study at the beginning or at any time during the study. There will be no costs involved with participation in this study.

Participant Consent:
I have read the above information and agree to allow my child to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

Signature of Participant _______________ Date _______________

Participant Name (Please Print) _______________

APPENDIX II

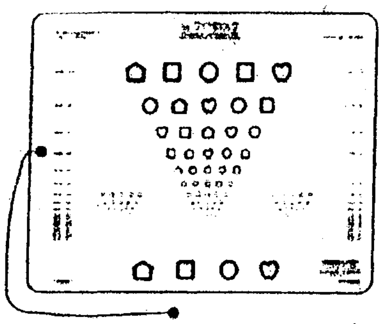
LEA VISUAL ACUITY TESTS

Visual Acuity Tests

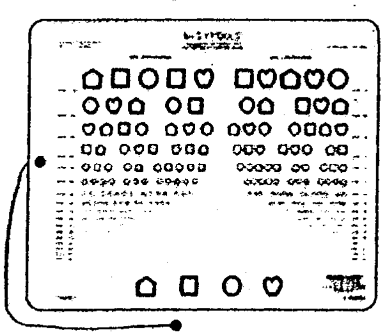
A great majority of the LEA Tests are visual acuity tests to allow measurement of visual acuity in all clinical situations. One of the most common areas is **vision screening** in preschool and school age.

The basic visual acuity test is the **line test** where the distance between the symbols, the optotypes, is equal to the width of the symbols, as recommended by the International Council of Ophthalmology in 1989.

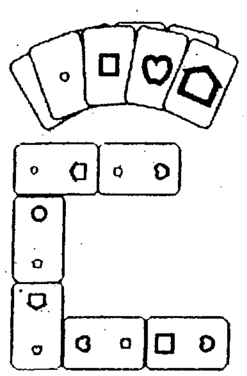
Near Vision Tests



In infants and children visual functions at near distances are more important than visual functions at greater distances. Therefore visual acuity should always be first measured at a near distance. Visual acuity at near is measured with the **line test** which is the basic measurement.



In children who are about to learn to read, the reverse side of the near vision test with more **crowded symbols** gives an idea about the size of the text that the child can handle.



Visual acuity measured with single symbols, either using single **LEA Playing Cards** or the **LEA Domino Cards** reveals what is the smallest symbol that the child can discern when there is no disturbing visual information around. This is very important information to be compared with visual acuity values measured with line and crowded tests when testing *amblyopic* eyes and vision in children who have *brain damage*.

Thus for near vision acuities we have three different acuity values:

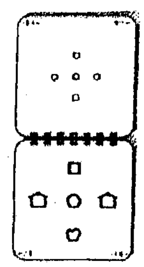
- the basic line test acuity,
- visual acuity measured with more crowded symbols and
- visual acuity measured with single symbols.

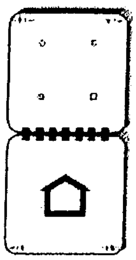
The Playing Cards and the **Domino Cards** are useful in *training* of amblyopic eyes and at the same time introduce the test situation to younger siblings in the family or younger children in a day care centre/nursery school.

Training of the test situation can be started very early, before the age of one year by using the three dimensional symbols of the **LEA Puzzle**. Since the concept similar - different is first learned in relation to colours, one side of the puzzle is based on colours and the other side on black and white forms. When the test symbols are introduced in a play situation with the puzzle, measurement of visual acuity is possible as early as at the age of 14 months.

Distance vision tests

Visual acuity for distance vision is measured with tests held at three meter distance. If that distance is too great for a young child, testing can be performed at two meter distance. In older children measurement can made at greater distances up to six meters if the child has vision tasks at that distance.

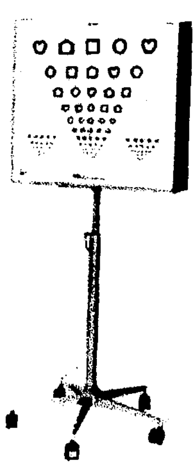


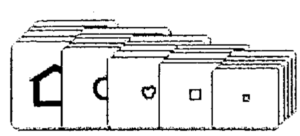


For testing children 5 years of age and older, the basic test of visual acuity at distance is the **15-line Folding Chart** or the back illuminated charts on either the bigger EDTRS-**lightbox** or the smaller lightbox. In these charts there are two or three sets of symbols in the lower rows so that measurement of binocular and monocular values can be made by using different sets of symbols. This prevents memorising. The charts with several sets of symbols in the lower rows are too difficult for 3-4-year-old children. For them there is a chart with 10 lines and only one set of symbols.

If even the **10-line Chart** is too difficult, the **Crowded Symbol Book** with five symbols in a group functions as a miniature line test where the central symbol functions as the test symbol. In the assessment of severely visually impaired children this distance test, like all distance tests, can be used as a near vision test.

If the child can concentrate on looking at only one symbol at the time, the **Single Symbol Test Book** or **Flash Cards** can be used. However, it is important to remember that visual acuity measured with single symbols is not comparable to visual acuity measured with the line test. It is usually 2-4 lines better than visual acuity measured with a line test.

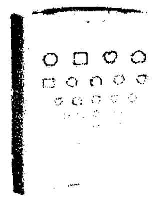




Back illuminated distance vision charts

In the U.S., the National Eye Institute requires that visual acuity measurements for research purposes are made on visual acuity tests that are **back illuminated at a standard luminance level**. The light boxes are of two different sizes, the large so called **EDTRS light box** where a full size visual acuity test can be used and a **small light box** on which the largest symbols are three lines smaller.

The small light box is easily caried and can be used with both pediatric and adult visual acuity charts at high and low contrast levels. Its use is demonstrated in a video clip at AAPOS Video Archives and at Follow-up of Vision Development of healthy children to detect amblyopia (lazy eye) and eye turn or strabismus.



The LEA Symbols have been chosen for several screening instruments, such as the INSTA-LINE by Good-Lite and the Massachusetts Visual Acuity Test that is under development. These modifications try to make testing easier for the tester. A typical screening test contains only those lines of the visual acuity chart that are used in screening symptom free children.

Screening programs and tests for assessment using LEA SYMBOLS are also a part of computer based tests by:

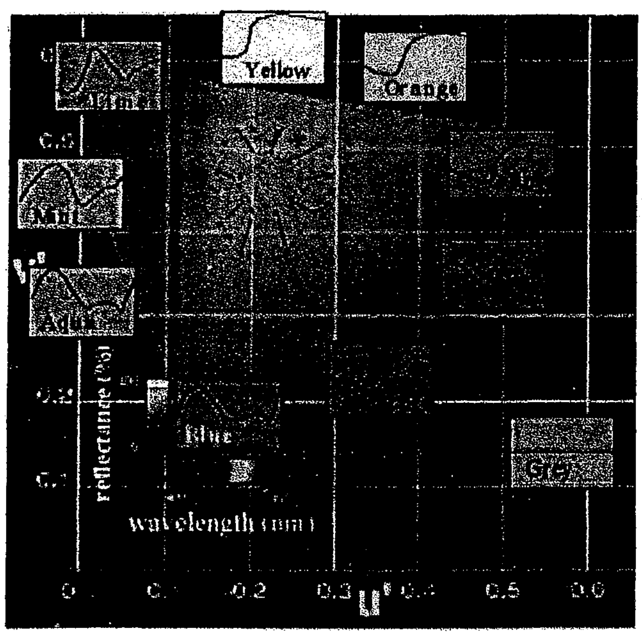
M&S Technologies, INC
P.O.Box 1171
Park Ridge, IL 60068, U.S.A.
FAX +1-773-467 0816
jmarino@mstec.com

APPENDIX III

CERIUM COLOUR OVERLAYS

COLOURED OVERLAYS

Coloured overlays are sheets of coloured plastic film suitable for placing over a page of text when reading. There are several sets on the market. For example, a set is manufactured by i.O.O. Sales (NB Not 100 Sales) and another by Cerium Visual Technologies. It is necessary to obtain overlays that sample colours systematically and efficiently, for example, as in figure 1:



The effects of coloured overlays on reading fluency are reviewed elsewhere, and a review of recent studies is available.

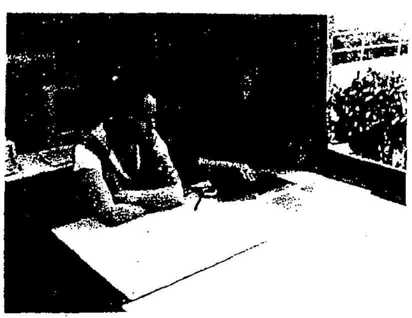
Teachers and others involved in the assessment of children using overlays may find additional instructions helpful. The beneficial effects of the overlays on reading fluency can be assessed using the Rate of Reading Test, also available from i.O.O. Sales and Cerium Visual Technologies.

Recently the IOO overlays have been shown to be of benefit to about 20% of primary school children. [Jeanes, R., Martin, J., Lewis, E., Stevenson, N., Pointon, D. and Wilkins, A.J. (1997). Prolonged use of coloured overlays for classroom reading. British Journal of Psychology, vol 88, 531-548. Wilkins, AJ, Lewis, E, Smith, F., Rowland, E., Tweedie, W. (2001) Coloured overalys and their benefit for reading. Journal of Research and Reading, 24, 41-64.]

You may wish to check the answers to frequently asked questions concerning overlays and visual stress.

COLOUR IN THE TREATMENT OF VISUAL STRESS

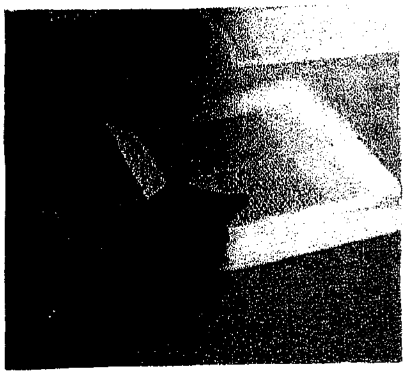
Coloured overlays have been shown to reduce visual stress and increase reading fluency in about 20% of school children, although there is doubtless more than one reason, and placebo effects probably contribute. For whatever reason, in 5% of children the increase in speed with overlays is greater than 25% . A variety of controlled trials have shown that placebo effects are not a sufficient explanation for the increase in reading speed. Coloured glasses have been shown to reduce headaches in open trials and also in two small scale trials using a double-masked protocol . The colour optimal for overlays differs from that optimal in lenses. The shade usually has to be selected with precision in order to obtain beneficial results. The symptoms of visual stress (eye-ache and perceptual distortions) and the benefit from colour are sometimes collectively refered to as 'visual stress' or 'Meares-Irlen Syndrome', and sometimes as 'Irlen Syndrome' (USA), or 'scotopic sensitivity syndrome'.



Helen Irlen was one of the first to promote the beneficial effects of coloured filters, see review. Her approach remains controversial. The research work described in these pages follows from studies conducted originally by Arnold Wilkins in collaboration with members of the Irlen Institute, but subsequently quite independently of this organisation.

The overlays that Prof Wilkins designed are called the *'Intuitive Overlays'* and can be obtained from ioo sales. Similar overlays are sold by Cerium Visual Technologies, the company which markets the *Intuitive Colorimeter* under licence from the UK Medical Research Council. The book "Reading through Colour" by Arnold Wilkins is published by Wiley. You can obtain a complete set of Wilkins' publications , and a selection of other recent relevant papers. There is also a set of frequently asked questions (with answers!).You can also obtain a video entitled "Reading with Colour" in which children talk about their experiences with overlays, and a test with overlays is demonstrated.

There is a set of forms for use by teachers in high schools and colleges. There is a page of information for



optometrists. The optometrists who use the Intuitive Colorimeter are listed on the Cerium Visual Technologies website. There is a support e-group for those who suffer from Visual Stress or Meares-Irlen syndrome (perceptual distortion and eye-strain, treated with coloured filters). There is also a telephone helpline on +44 1206 872130 (01206 872130 within the UK).

Shareware software allows computer users to select the colour of the foreground and the background of their computer monitor. There is software compatible with Windows 95 available for download from this site, and software compatible with with more recent Windows operating systems available for download from Thomson software solutions. The software is useful because it allows you to adjust the colour when you are working with the application you usually use, but you can also adjust the background colour in recent Windows operating systems by following instructions on how to use the Control Panel.

Professor Thomson (City University, London) has written software for undertaking an overlays assessment on-screen, available from Thomson software solutions. An evaluation of this software has been undertaken and shows a reasonable agreement with the colour choice made using overlays themselves. The report is not yet published.

There is a "Colour and Visual Sensitivity Forum" which meets every two or three months to discuss issues surrounding the treatment of visual stress with coloured filters.

If you have any questions or comments please feel free to contact Arnold Wilkins.

BIBLIOGRAPHY

Babbitt, E. D. (1878). *The principles of light and color.* Published by the author: East Orange, NJ.

Babcock, D., Lovegrove, W. (1981). The effects of contrast, stimulus duration, and spatial frequency on visible persistence in normal and specifically disabled readers. *Journal of Experimental Psychology and Human Perceptual Performance,* 7, 495-505.

Birren, F. (1961). *Color psychology and color therapy.* University Books: New Hyde Park, NY.

Bodis-Wollner, I., Diamond, S. P. (1976). The measurement of spatial contrast sensitivity in cases of blurred vision associated with cerebral lesions. *Brain,* 99, 695-710.

Brannan, J., Williams, M. (1988). Developmental vs. sensory deficit effects on perceptual processing in the reading disabled. *Perceptual Psychophysics,* 44(5), 437-444.

Breitmeyer, B. G., Ganz, L. (1976). Implications of sustained and transient channels for theories of visual masking, saccadic suppression, and information processing. *Psychological Review,* 83(1), 1-36.

Breitmeyer, B. G. (1978). Disinhibition in metacontrast masking of vernier acuity targets: Sustained channels inhibit transient channels. *Vision Research,* 18, 1402-1405.

Christenson, G. N., Griffin, J. R., Taylor, M. (2001). Failure of blue tinted lenses to change reading scores of dyslexic individuals. *Optometry,* 72(10), 627-633.

Croyl. L. (1998). Rate of reading, visual processing, colour and contrast. *Australian Journal of Learning Disabilities,* 3(3), 13-21.

Dbo, JC. J., Sutherland, G. FM., McGettrick, P. M. (1992). A preliminary appraisal of the Irlen screening process for scotopic sensitivity syndrome and the effect of Irlen coloured overlays on reading. *British Orthoptic Journal,* 49, 25-30.

Evans, B. J. W., Drasdo, N. (1991). Tinted lenses and related therapies for learning disabilities: A review. *Opthalmological Physiology and Orthoptics,* 11, 206-217.

Evans, R. B. (1994). Sensory discrimination and intelligence: Postmortem or resurrection: *American Journal of Psychology,* 107(1), 95-115.

Evans, B. J. W., Patel, R., Wilkins, A. J., Lightstone, A., Sperjesi, F., Speedwell, L., Duffy, J. (1999). A review of the management of 323 consecutive patients seen in a specific learning difficulties clinic. *Opthalmological and Physiological Optics,* 19(6), 454-466.

Galton, F. (1883). *Inquiries into the human faculty and its development.* Macmillan: London.

Goldstein, K. (1941). Some experimental observations concerning the influence of colors on the function of the organism. *Occupational Therapy and Rehabilitation,* June, 1942.

Goldstein, L. H., Oakley, D. S. (1986). Color versus orientation discrimination in severely brain-damaged and normal adults. *Cortex,* 22, 261-266.

Grewal, B. S., Haward, L. R., Davies, I. R. (1987). The role of color discriminability in the Weigl Test. *IRCS Medical Science: Psychology and Psychiatry,* 14, 693-694.

Haugland, S. W. (1992). The effects of computer software on preschool children's developmental gains. *Journal of Computing in Childhood Education,* 3(1), 15-30.

Huang, I. N., Borter, S. J. (1987). The color isolation effect in free recall by adults with Down syndrome. *American Journal of Mental Deficiency,* 92(1), 115-118.

Hyvärinen, L. (1980). New visual acuity test for pre-school children. *Acta Ophthalmol,* 58, 507-511.

Irlen, H. (1983). Successful treatment of learning disabilities. Paper presented at the 91st Annual Convention of the American Psychological Association, Anaheim, CA.

Iovino, I., Fletcher, J. M., Breitmeyer, B. G., Foorman, B. R. (1998). Colored overlays for visual perceptual deficits in children with reading disability and attention deficit-hyperactivity disorder: Are they differentially effective. *Journal of Clinical and Experimental Neuropsychology,* 20(6), 791-806.

Jones, R. (1998). Starting early. *The American School Board Journal,* October, 1998, 22-25.

Jeanes, R., Busby, A., Martin, J., Lewis, E., Stevenson, N., Pointon, D., Wilkins, A. J. (1997). Prolonged use of coloured overlays for classroom reading. *British Journal of Psychology,* 88, 531-548.

King-Smith, P. E., Carden, D. (1976). Luminance and opponent-color contributions to visual detection and adaptation and to temporal and spatial integration. *Journal of the Optical Society of America,* 66(7), 709-717.

Lovegrove, W. J., Martin, F., Slaghuis, W. (1986). A theoretical and experimental case for a residual deficit in specific reading disability. *Cognitive Neuropsychology,*3, 225-267.

Lovegrove, W. J., Garzia, R. P., Nicholson, S. B. (1990). Experimental evidence for transient system deficit in specific reading disability. *Journal of the American Optometric Association,* 81, 137-146.

Meador, D. M. (1984). Effects of color on visual discrimination of geometric symbols by severely and profoundly mentally retarded individuals. *American Journal of Mental Deficiency,* 89(3), 275-285.

Mollon, J. D. (1982). Color vision. *Annual Review of Psychology,* 33, 41-85.

Neale, M. (1987). *The Neale analysis of reading ability (2nd ed.).* Wiley: NY.

NBS Special Publication 516. (1978). Color in the health care environment. U.S. Department of Commerce/National Bureau of Standards: Washington, DC.

O'Connor, P. D., Sofo, F., Kendall, L., Olsen, G. (1990). Reading disabilities and the effects of colored filters. *Journal of Learning Disabilities,* 23(10), 597-620.

Raymond, R. J., Ginsburg, A. P., Murray. T. J. (1981). Contrast sensitivity, visual acuity and the discriminationbinson, of Snellen letters in multiple sclerosis. *Brain,* 104, 333-350.

Robinson, G. L., Miles, J. (1987). The use of colored overlays to improve visual processing: A preliminary survey. *The Exceptional Child,* 34, 65-70.

Robinson, G. L., Foreman, P. J. (1999). Scotopic Sensitivity Irlen Syndrome and the use of coloured filters: A long term placebo controlled and masked study of reading achievement and perception of ability. *Perceptual and Motor Skills,* 89, 83-113.

Rothstein, L. F. (1995). *Special education law, 2nd Edition.* Longman: NY.

Rutter, M., Yule, W. (1975). The concept of specific reading retardation. *Journal of Child Psychology and Psychiatry,* 16, 181-197.

Saint-John, L. M., White, M. A. (1988). The effect of coloured transparencies on the reading performance of reading-disabled children. *Australian Journal of Psychology,* 40, 403-411.

Solman, R. T., Cho, H. S., Dain, S. J. (1992). Colour-mediated grouping effects in good and disabled readers. *Ophthalmological and Physiological Optics,* 11(4), 320-327.

Spearman, C. (1904). "General intelligence", objectively determined and measured. *American Journal of Psychology,* 15, 201-293.

Stanley, G. (1987). Coloured filters and dyslexia. *Australian Journal of Remedial Education,* 19, 8-9.

Strauss, A. A. (1941). Pathology of figure-background relation in the child. *Journal of Abnormal and Social Psychology,*36, 236-248.

Suchman, R. G., Trabasso, T. (1966). Color and form preference in young children. *Journal of Experimental Child Psychology,* 3, 177-187.

Twenty-third annual report to Congress on the implementation of the Individuals with Disabilities Education Act. (2001). U.S. Department of Education: Washington, DC.

Varley, H. (1980). *Color.* Viking Press: NY.

Wiederholt, J. L. (1986). *Formal reading inventory.* PRO-ED: Austin, TX.

Wilkins, A. J., Milroy, R., Nimmo-Smith, E., Wright, A., Tyrrell, R., Holland, K., Martin, J., Bald, J., Yale, S., Miles, T., Noakes, T. (1991). Preliminary observations concerning treatment of visual discomfort and associated perceptual distortion. *Ophthalmological and Physiological Optics,* 12, 257-263.

Wilkins, A. J., Evans, B. J. W., Brown, J., Busby, A., Wingfield, A., Jeanes, R., Bald, J. (1994). Double blind placebo controlled trial of precision spectral filters in children with reading disability. *Ophthalmological and Physiological Optics,* 14(4), 365-370.

Wilkins, A. J., Lewis, E., Smith, F., Rowland, E., Tweedie, W. (2001). Coloured overlays and their benefit for reading. *Journal of Research in Reading,* 24(1), 41-64.

Williams, M. C., LeCluyse, K., Bologna, N. (1990). Masking by light as a measure of visual integration time and persistence in normal and disabled readers. *Clinical Vision Science,* 5(4), 335-343.

Williams, M. C., LeCluyse, K., Rock-Facheus, A. (1992). Effective interventions for reading disability. *Journal of the American Optometric Association,* 6(6), 411-417.

Winters, J. J., Hoats, D. L. (1984). Effects of isolation by color on mentally retarded and nonretarded persons' recall by printed words. *American Journal of Mental Deficiency,* 89(3), 310-312.

VITA

Graduate College
University of Nevada, Las Vegas

Edith A. Naas

Home Address:
20447 Temelec Way
Reno, NV 89521

Degrees:
Bachelor of Science, Physical Therapy, 1962
Columbia University, NY, NY

Master of Arts, Motor Learning, 1994
Teachers College
Columbia University, NY, NY

Master of Education, Biobehavioral Science, 1998
Teachers College
Columbia University, NY, NY

Dissertation Title: Colored Overlays and Symbol Identification in Pre-School Children with Disabilities

Dissertation Examination Committee
Chairperson, Dr. John Filler, Ph.D.
Committee Member, Dr. Nancy M. Sileo, Ph.D.
Committee Member, Dr. Jeffrey I. Gelfer, Ph.D.
Committee Member, Dr. W. Paul Jones, Ph.D.