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Effect of Color Overlays on Reading Efficiency

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THE EFFECT OF COLOR OVERLAYS ON READING EFFICIENCY

A Dissertation Presented

by

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DEDICATION

To my family and friends who encouraged and believed in me.
I never would have made it without you.

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ABSTRACT

THE EFFECT OF COLOR OVERLAYS ON READING EFFICIENCY

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Reading is a skill that unlocks the doors of learning and success. It is commonly accepted that reading is a foundational skill that plays a major role in a child's academic success. The history of teaching reading includes many theories about the development of reading, the source of reading difficulties, and interventions for remediation. A large body of research has demonstrated that reading difficulties stem from a phonological basis and interventions that target this area are generally beneficial in helping improving reading skills (National Reading Panel, 2000; Shaywitz, 2003; Stanovich, 1986). However, there are some who even with extensive intervention continue to struggle to read. Helen Irlen (2005) proposed that these people may experience visual-perceptual distortions when reading high-contrast text (black on white background). Irlen claims that symptoms of this disorder, termed Scotopic Sensitivity or Irlen Syndrome, can be alleviated by the use of color overlays or filters (tinted glasses). Research into the existence of this syndrome and the effectiveness of the overlays and filters to remediate reading problems has been inconsistent and criticized for lacking scientific rigor and heavy reliance on subject report of improvement. The present study seeks to evaluate differences that may exist in eye movements and reading fluency when subjects diagnosed with

IS read text with and without color overlays. Participants were screened with the Irlen Reading Perceptual Scale (IRPS) to determine whether or not they suffered from the syndrome. From this screening, participants chose an overlay reported to alleviate distortions or discomfort they experienced when reading. They were then asked to read 18 passages under three conditions—with a clear overlay, with their chosen overlay, and with a random overlay—while their eye movements were recorded. Results indicated that participants showed no improvement in eye movement or reading fluency when they read passages with an optimum (chosen) overlay verses a clear overlay or a random overlay.

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CHAPTER 1

STATEMENT OF THE PROBLEM

<u>The Importance of Learning to Read</u>

Reading is a skill that unlocks the doors of learning and success. In our society, those who are considered 'literate' are generally successful and perceived as more intelligent than those who are less literate. Individuals who learn to read well are more likely to be adequately employed, and socially and financially stable. Fluent readers tend to possess general knowledge and skill that allows them to thrive in an information-based society. Conversely, people who are less literate may fail to develop such knowledge and skill and are at a disadvantage both economically and socially. These adults are at risk for low employment and underemployment, receiving welfare benefits, and involvement in criminal activity resulting in imprisonment (Adams, 1994; Hall & Moats, 1999). Thus, because the price of illiteracy is so high, learning to read is a critical element in one's success.

Hall and Moats (1999) stated, "Reading is the most important skill for success in school and society (Hall & Moats, 1999 p. 6). So important is the ability to read that we deem it a necessary foundational skill and teach it to our children in the primary years with the expectation that by the third grade they will have become skillful enough to read connected text at a minimum level of effectiveness for meaning. This expectation is based on the fact that it is at the third grade that the focus of reading instruction changes from learning to manipulate letters and sounds for decoding and encoding words, to reading for comprehension as a means of obtaining knowledge (Adams, 1994; Moats, 2001). Children who experience positive early interactions with reading tend to develop into good readers who enjoy engaging in the task of reading. Because these children are able to read with relative ease and comfort, they will read more and continue to build their reading skill and knowledge base (Irlen, 2005; Stanovich, 1986; Morgan, Morgan, Fuchs, Compton, Cordray, & Fuchs, 2008). As they progress through the higher grades, when material becomes more challenging, their efficiency of reading allows them to keep pace and adequately profit from instruction. As a result, these children tend to grow up to become literate adults (Stanovich, 1986).

However, for many people, reading does not develop quite as easily. Instead, reading is an arduous task, and one that requires a significant amount of energy and effort to obtain meaning. Comprehension comes at the cost of significant time spent manipulating text and can result in an understanding that may or may not represent the author's intent. Additionally, such negative experience with the task of reading may have the effect of significantly reducing the amount of reading in which one engages, which in turn may hinder comprehension due to poor development of the background knowledge that is normally obtained from exposure to large amounts of print resources (Moats, 2001; National Reading Panel, 2000; Morgan & Fuchs, 2007; Stanovich, 1986).

Reading Instruction

Because reading is so important, researchers have endeavored to find the best way to teach children to read and to help those who struggle to learn to read. Educators have long debated the best methods for reading instruction, and this debate has led to pendulum swings in reading curriculums and teaching approaches. Prior to the 1980's reading was taught with a focus on learning the code and the use of basal readers as a means of developing comprehension. Children were taught the alphabet and sounds of the letters with a belief that learning the code would lead to comprehension. In the 1980's the rise of whole language led to reading instruction that emphasized a constructivists approach. Focus was turned from direct teaching of the code to exposure to literature rich texts presented in unedited form, with the belief that students would learn to read through experiencing literature in its purest form. This view emphasized comprehension as a means of reading rather than the result of reading. Instead of decoding words to determine meaning, students were encouraged to utilize picture and context cues towards understanding. Reading skills were not directly taught to students because it was believed that skills would emerge from meaningful communication activities and spontaneously taught mini-lessons (Pearson, 2004).

A report of the National Reading Panel (2000) examined reading research and identified key components in reading instruction. It found that in order for children to become proficient readers, they must develop alphabetic understanding and phonemic awareness and these skills must be taught explicitly and systematically in the early years of education. Further, interventions to help struggling readers should focus on phonological processing deficits.

Early research compared poor readers to good readers in an attempt to understand the cognitive processes involved in reading. Many differences were observed and inferences made about the cause of reading difficulties in poor readers (Stanovich, 1986; Jenkins, Fuchs, Van den Broek, Espin, & Deno, 2003; Vullentino, 2007). One area in which disparities were found in reading behavior between good and poor readers was eye movement (Rayner, 1998). Observations during reading provided basic information about eye movement behavior. Technology made it possible to capture and measure these movements and provided a basis for describing these differences. Research in this area reported that poor readers make more regressive eye movements, have a higher number of fixations, and longer fixations durations per line of text than more skilled readers (Rayner, 1998). These observed differences were erroneously interpreted by some to mean reading difficulties were the result of visual processing deficits which when corrected would improve reading (Stanovich, 1996). In fact, the converse is true, with eye movements being a reflection of reading ability. Unfortunately, this interpretation resulted in the widespread use of such interventions as eye movement training programs which attempted to improve reading by correcting visual efficiency. Such programs have not been demonstrated to be an effective method for improving reading (Rayner, 1998; Stanovich, 1986).

A large body of research has demonstrated that most reading difficulties stem from a phonological basis and interventions that address this area are generally beneficial in helping children develop and improve reading skills (National Reading Panel, 2000; Shaywitz, 2003; Stanovich, 1986). However, there are some who, even with considerable intervention, still struggle to learn to read. Others learn to read adequately but inefficiently, and reading for them remains laborious and unenjoyable (Irlen, 2005). Even with what we know about what constitutes good reading instruction and intervention, one researcher has proposed that there is still another area of reading processing that should be addressed when considering why someone may have difficulties with the task of reading. Helen Irlen (2005) believes that helping children develop into who readers able to comfortably engage in the task of reading requires further consideration of the visual system in the process of reading.

Why do some people still struggle with the task of reading after much intervention and effort? Irlen (2005) posited that people who continue to struggle to learn to read efficiently may in fact suffer from Scoptopic Sensitivity Syndrome or Irlen's Syndrome (IS). According to Irlen (2005), this syndrome is characterized by visual perception distortions that occur most often with high-contrast text (black text on white paper) and result in symptoms that make reading uncomfortable. Such symptoms include seeing movement of text (i.e. shaking or wiggling), white spaces becoming more pronounced than black text, text fading in and out, etc. Readers may find that they have difficulty tracking text and may often misread words, skip lines, and develop somatic symptoms such as headaches, nausea, or eyestrain (Irlen, 2005). According to Irlen (2005), as many as 46% of people diagnosed with learning disabilities suffer from IS and it is a key factor interfering with reading improvement. In the general population, 12-14% may struggle with IS, affecting the amount of time one spends reading (Irlen, 2001). Irlen (2005) is careful to say that IS is not the cause of reading difficulties. Rather she considers it a piece of the puzzle that may play a role in why some fail to adequately respond to reading interventions. According to Irlen (2005), when visual distortions can be controlled, individuals will become more available to engage in the task of reading and interventions that address language-based deficits may be more effective. She states that a person with IS, "cannot become a fluent, confident reader, no matter what the intervention until the [IS] is treated" (p.61).

Irlen Syndrome

In her book entitled, *Reading by the Colors: Overcoming Dyslexia and Other Reading Difficulties* (Irlen, 2005), Helen Irlen describes how she discovered the syndrome in 1981 during her work at a federally-funded research program at California State University in Long Beach. The research was performed at an adult learning disability center and its purpose was to study the factors in learning disabilities that had not responded to remediation and maturation, and had gone undetected within the context of established school evaluation systems. Irlen's previous experience as a school psychologist had led her to believe that the present systems for evaluating reading difficulties were not accounting for all of the factors that may affect a child's learning. She believed that there was something else standing in the way of real progress for many people with learning disabilities and hoped that the research would reveal unexplored factors that could be targeted for intervention giving hope to those who continue to struggle to learn to read.

Subjects in her study were adults who had been diagnosed as children with learning disabilities. These subjects had experienced special education evaluation and placement, interventions designed to remediate reading skills, and private tutoring yet they continued to struggle with the task of reading. Irlen found that for all of these individuals, there was one important question that had never been asked during previous assessments. They had never been asked what happens when they read. Irlen wanted to fully understand what these individuals were experiencing when they engaged in the task of reading. In order to answer this question, Irlen spent hours interviewing each of the 1,500 subjects. A subset of subjects emerged with patterns in their responses. These subjects reported that overall reading was difficult and frustrating and many reported reading more slowly than their peers. There was a high incidence of such symptoms as frequent loss of place on the page, misreading words, skipping lines, and the need to reread text repeatedly. These experiences often led to frustration, feeling fidgety, falling asleep during reading, and difficulties comprehending text. To further understand this phenomena, Irlen asked a population of proficient readers what they saw on a page text. Their responses were simply, “Letters and words.” None reported the symptoms experienced by the population with learning disabilities. This led her to conclude that there were differences in what people see on a page of text that lead to varying reading experiences. These experiences may indirectly affect the development of reading skills (Irlen, 2005).

Causes and Treatment of IS

In the Irlen study (Irlen, 2005), 35 subjects identified with IS were sent to a group of professionals from various disciplines over a nine-month period for remediation. These professionals included ophthalmologists, optometrists, developmental specialists, neurologists, reading specialists, and psychologists. Irlen (2005) stated that at the end of the nine months, "Although some treatments were helpful, none made any significant difference in reducing or eliminating the reported distortions" (p. 21). These results guided her belief that the visual perceptual distortions these subjects suffered were part of a unique syndrome that required treatment not available within established methods of remediation.

Irlen (2005) describes the discovery of the benefits of color to improve visual perception as happening quite by accident when a student brought in a red overlay she had used in vision training several years earlier. Another student within the group discovered that when she used the overlay, the distortions she had experienced were eliminated. This discovery led Irlen to experiment with other colors and text. Using color plastic gels used in theater lights, she found that the effect of the color overlays was idiosyncratic with some colors helping and other colors worsening the problem for different individuals. Of the 37 subjects who identified and used an optimum color overlay, 31 reported being able to read longer and faster, as well as being able to keep up with their peers. Conversely, good readers reported no effects on how long or how well they read with the overlays. Students who reported improvement with the overlays indicated that they had difficulties using the overlays for such tasks as reading material from an overhead, or when writing. In order to improve the practicality of the use of color to control or eliminate visual perceptual distortions, Irlen developed color filters (tinted glasses). Overlay colors do not correspond to colors used in the filters, and the process for determining filter colors is lengthy and expensive. Where diagnosis and overlay determination can be done by a certified Irlen screener, filters must be obtained through a specially trained diagnostician (Irlen, 2005).

While it is not fully understood what causes the perceptual distortions and why the use of color overlays reduce or eliminate the distortions, Irlen (2005) states that this disorder is possibly due to a structural deficit in the brain which causes signals in the brain to be inappropriately processed. She believes that those who suffer with IS have a sensitivity to full-spectrum light that alters how visual stimuli is processed in the brain (Irlen, 2005). Irlen proposes that the color overlays and filters selectively block certain wavelengths and results in reduced perceptual distortions (Irlen, 2005). Another theory of visual processing deficits in reading was described by Singleton and Henderson (2006). According to this theory, termed the Magnocellular Deficit theory, it is believed that a dysfunction occurs in the neural pathway that sub serves vision. The two systems of cells that aid in the process of reading, the magno system and the parvo system, work together to aid perception of text. The parvo system codes information about color and detail, while the magno system is responsible for inhibiting the parvo system when the eyes are in motion so that images are perceived as stationary even though the eyes are moving across text. In visual perceptual disorders, it is believed that there is a defect in the magno system which may cause problems in the smooth and efficient processing of text (Singleton & Henderson, 2006).

Irlen describes her research in her book, but does not give detail about methodology or report any data analysis.

Previous Research on IS/Scoptopic Sensitivity Syndrome

Although there have been several studies conducted on the use of color overlays (Blaskey et al., 1990; Evans, Cook, Richard & Drasdo, 1994; Tyrell, Holland, Dennis & Wilkins, 1995;

Fletcher & Martinez, 1994; Robinson & Conway, 1990; Wilkins, Lewis Smith, Rowland & Tweedie, 2001), reviewers have criticized the research as being largely subjective and lacking scientific rigor (Hoyt, 1990; Scheiman et al.,1990; Solan, 1990). Researchers fail to agree on the existence of this syndrome and the effectiveness of color overlays as a treatment.

Researchers in the field of ophthalmology dispute IS as a distinct syndrome and claim that the perceptual difficulties experienced by those diagnosed with IS are actually part of a vision problem that should be addressed through optometric interventions. When listing the symptoms of scoptopic sensitivity syndrome, Scheiman et al. (1990) stated, "This list, of course, is identical to one that any optometrist would consider to be signs and symptoms associated with refractive, accommodative, binocular or ocular motility disorders." (p. 601). Blaskey et al. (2001) examined the effectiveness of the use of Irlen filters (tinted glasses) to relieve symptoms over traditional optometric intervention. 40 subjects aged 9-51 were recruited to participate in a study about the effectiveness of the Irlen filters. As the study took place two months after an airing of a 20-minute segment about Irlen Syndrome on the television program *60 Minutes*, some of the participants were viewers who called for more information in response to the program. Of the 40 volunteers, 38 met the criteria for both vision problems and Irlen Syndrome. Subjects were randomly placed into three groups and received either the Irlen intervention (filters), vision therapy, or no intervention (control group). Subjects were given complete vision examinations and screened with the Irlen screening battery. Subjects in the Irlen treatment group had significant vision problems and underwent examination for Irlen filters. All subjects tested positive for filters (found filters which they reported improved their symptoms). They were also given a second pair of filters with ordinary tint which served as a placebo. The real and placebo filters were randomly selected and given to subjects by an individual who was blind to all aspects of the study. Subjects received the filters approximately 1 month after initial testing and were asked to try them for two weeks. They then received the other pair of filters to wear for two weeks. Subjects were then asked to select the pair of filters that were most comfortable and to wear those for two more weeks. Subjects in the vision therapy treatment group were given glasses or modification to glasses as indicated by their vision examination. Each subject underwent a vision therapy program which included vision exercises or procedures performed once or twice week in 45-minute sessions. They were also given vision therapy procedures to work on at home.

All subjects were given a battery of reading tests [the Woodcock Reading Mastery Test (forms G & H, and word recognition subtest), Gray Oral Reading Test (forms c & d), Standford Reading Test (level red, green brown or blue, forms G & H and the Irlen Clinic Test of Random Letters], intelligence tests [Wechsler Intelligence Scale for Children-Revised (WISC-R) or Wechsler Adult Intelligence Scale-Revised (WAIS-R)], and completed an optometric questionnaire. Results showed significant differences between the pre and post scores for the subjective measures (scotopic sensitivity score and symptom questionnaire) in both the Irlen and the vision therapy groups. The Irlen subjects reported fewer symptoms and more comfort when reading through their preferred filters. However, there were no significant differences seen on any of the reading measures for this group. Additionally, the vision therapy group obtained a significant difference in their reading fluency measure (Gray Oral Reading) indicating that their rate of reading also improved with treatment. No significant scores were obtained on any of the other reading measures for this group. Blaskey et al. (2001) concluded from these findings that the immediate effect of use of Irlen filters is reduction in visual complaints. However, results did not show significant improvement in reading ability with the use of filters. Further, the fact that subjects in the vision therapy group also improved in comfort on the Irlen measures suggests that scotopic sensitivity is not a distinct entity and that vision problems may be an underlying factor in people who feel they may benefit from Irlen filters.

Evans, Richards, and Drasdo (1994), proposed that pattern glare (described as a pattern such as stripes that are typically problematic for people who suffer from epilepsy and migraine headaches) may account for the visual symptoms experienced by those with IS. They reported that about 3% of people who suffer from epilepsy are sensitive to certain patterns and that many people who do not suffer from epilepsy find patterns such as stripes uncomfortable. Such patterns can induce illusions of color, shape, and motion similar to those experienced by people with IS. Further, tinted lenses have often been used to treat these symptoms in people with epilepsy, migraines, and visual discomfort. Evans et al. (1994) stated that positive results from previous studies on the effectiveness of color lenses to treat IS may have been due to expectancy and the placebo effect. In those studies, there was significant publicity associated with the Irlen therapy and subjects knew that they were expected to perform better with the color lenses. They also argued that the tints themselves were reinforcing, “brightly colored tints, like highlighter pens, can appear to have the effect of enhancing the contrast of print; hence, colored filters may act as a self-reinforcing placebo” (p. 620). They hypothesized that because symptoms are produced by the spatial properties of text on the page, manipulation of those properties would change the amount of pattern glare one experiences. If pattern glare accounted for the symptoms behind IS, the benefit that one experiences with the color overlays would vary with subtle changes in the text and the naïve subject would be unaware of this hypothesis.

In this study, subjects were given a photocopy of a pattern to induce pattern glare and a questionnaire of about their history of epilepsy or migraines. They were then asked to look at the pattern for 10 seconds and check off from a list of nine illusions all those which they experienced. Subjects then chose color overlays that reduced or alleviated the illusions. From this group 5 subjects were chosen who reported the most pattern glare (experimental group) and compared to 6 subjects who showed the least pattern glare (control group). All subjects were given a simulated reading visual search task (SRVST) in which the spatial patterns of the text were closely spaced (more likely to elicit pattern glare) and widely spaced (less likely to elicit pattern glare). Results showed that those in the experimental group generally read more slowly than did the control group across all conditions, although this difference was not significant. Results showed that subjects read faster with their chosen overlay when reading the closely spaced text, than they did with their overlay on the widely spaced text. However, this difference was not significant. Subjects in the control group read comparably on each of the tasks with and without an overlay.

Studies have reported positive results on reading comfort and reading skill measures with the use of color. Tyrrell, R., Holland, K., Dennis, D. and Wilkins, A. J. (1995) investigated the effects of color overlays on reading skills and general reading behavior in school children. In their study, 60 children between the ages of 8 and 16 were selected from three high schools and one middle school to participate. Based on a score of greater than 97 on the *Cognitive Abilities Test* (National Foundation of Education Research, 1974) and performance on the *The Standard Reading Tests* (Daniels & Diack, 1977) placed in groups based on the difference between their chronological age and reading age (above average readers *n*=10, average readers *n*=18, and below average readers *n*=12). Additionally, there was another group (n=6) of students identified as well below average readers and a control group of students of similar age with average reading ability (*n*=8). Subjects were screened with the IRPS resulting in the choice (or non choice) of an overlay(s). Based on results of the IRPS, perceptual difficulties were scored and categorized as low, medium, and high. Subjects were also given visual search task and oral reading tasks. The visual search task consisted of a passage of text where letters within the passage were replaced at random by other similar looking letters (according to ascending or descending strokes). Subjects were instructed to look for the letter 'x' as quickly as possible and call out the letter that followed it. Results indicated higher percentages of subjects in the average, below average, and well below average reading categories had perceptual difficulty scores in the high category and were likely to choose a color overlay versus a clear overlay when reading. Subjects who chose a color overlay had significantly better oral reading rates when they read with the overlay versus with a clear overlay. Conversely, they found that after 15 minutes of reading, these same subjects had increased number of symptoms and decreased reading rate when they read through the clear overlay. There were no significant differences in reading rates for each task of subjects that chose a clear overlay or that were given random overlays when they read with clear or color overlays. They concluded that for some individuals the use of color overlays can be an effective intervention in the classroom.

Robinson & Conway (2001) reported positive results in their study of the effects of use of color overlays over time (12 month period) on reading skills and perception of reading ability. They hypothesized that correction of distortions experienced in those with IS would result in improvements in reading rate, accuracy, and comprehension, and improved perception of ability towards school tasks. Subjects in this study were students between 9 and 16 years of age who were screened with the IRPS and placed into two groups, those identified with Irlen Syndrome (n=44) and those without (n=47). Reading age was determined with the Neale Analysis of Reading Ability (Neale, 1958). Subjects in the IS group had an average discrepancy between their chronological age and reading age of 3 years 3 months, and those without IS had an average discrepancy between chronological age and reading age of 2 years 9 months. Subjects were also asked to complete the Student's Perception of Ability Scale (SPAS), a 70 item scale relating to specific areas of school performance. They were tested with alternate forms of the Neal Analysis of Reading Ability at three-month intervals over four occasions for (3 months, 6 months, 9 months and 12 months), and completed the SPAS at the last two testing sessions. Subjects were given color overlays based on their chosen preference within two weeks of assessment. The authors claimed these overlays served to give subjects intermediate benefit prior to the 2-hour diagnostic sessions for the filters (tinted lenses). Subjects were then supplied with the filters after three months. They reported gains in rate, accuracy, and comprehension over each test occasion with the greatest gains seen between the 9 and 12 month period. It should be noted that there was no control group included in this study because the researchers believed it to be unethical to deny treatment to students for one year. Therefore, it is difficult to say whether these gains would have been seen in subjects who did not receive the Irlen intervention. The authors addressed this issue by adding 12 months to the initial scores. They stated, "Because a control group was not employed in this study, 12 months were added to each initial Neale Analysis of Reading Ability for calculations of significance" (p. 592). Improved SPAS scores were reported indicating that students felt more positive about their ability in school after the 12 months. Finally, they divided the data into two groups based on subject reading ages for initial accuracy and comprehension of 8 years and below and above 8 years in. The researchers hypothesized that subjects with reading ages above 8 years should have mastered basic word-recognition skills and should therefore would show the most gains in reading achievement with improved clarity of print. Results showed a significantly better performance in accuracy in the higher reading age group as compared to the group with the lower reading age.

Wilkins, A. J., Lewis, E., Smith, F., Rowland, E., and Tweedie, W. (2001) also reported positive results with the use of the color overlays. In this article, the researchers reported on three studies conducted with school-aged children. The purpose of the first study was to investigate the reliability of the choice of color overlay and the effect of use of the overlay on reading speed. Subjects in this study were 89 students between 9 and 11 years of age who underwent three sessions of testing. The first session took place in a group format and involved subjects answering questions about their vision (whether they wore glasses and for what tasks), and then reading aloud a passage containing 20 lines of randomly ordered common words for the purpose of tiring their eyes. Subjects were asked to continue looking at the page while answering questions about what they saw. The second and third sessions involved individual testing where subjects were read aloud a passage for one minute from the Rate of Reading Test and then answered the same questions presented in the group session. They then participated in one of two techniques to determine color overlay choice. One technique used the Intuitive Overlays Instruction Book (IOO Marketing, London) that involved presentation of overlays across half a page of the stimulus. Subjects were asked to identify which side was clearer or more comfortable. The process continued with each of the overlays until an optimum overlay was identified. The second technique involved use of an A4 sized booklet of two side by side stacks of overlays with an identical page of text on white paper between each. Each page was fully covered and subjects were asked which overlay (or plain white page) was more comfortable to read. Again, all colors were presented and compared until an optimum overlay was indentified. Finally, subjects read the Rate of Reading Test passage aloud for one minute two more times, with and without their chosen overlay and their words read correct per minute was recorded. One to two days later, subjects attended the third session that involved the same procedure using the alternate technique for choosing an overlay. Results of this study showed that all subjects who chose an overlay in the first sessions (78) also chose an overlay in the second session. 47% of these subjects chose the same color overlay, 21% chose an overlay of similar color, and 22% chose a completely different color overlay. Students who chose the same or similar overlays showed a greater increase in reading fluency with the use of the overlay than those who choose different colors. The increase in reading at testing time 1 was strongly correlated to the increase in reading at testing time 2 (r=0.86; $p<.001$). They also reported that subjects with many symptoms reported in the group testing sessions, continued to report these symptoms throughout the individual testing sessions. These subjects were more likely to choose an overlay and demonstrated improved reading speed with its use. These results led them to conclude that group screening techniques would be sufficient to identify individuals for whom color overlays could be beneficial.

The purpose of the second study was to examine the relationship between visual difficulties with reading, and scholastic attainment in reading, including phonological and non-phonological reading strategies. 378 middle school children ages 8 to 12 participated in individual testing with one of three examiners in the same manner as described in study one. In addition to identification of an optimum overlay, examiners assigned a random overlay by choosing an overlay positioned behind the overlay subject described is being the least comfortable to read through. Students were given either a color overlay (chosen or random) or a grey overlay to use for 5 months.

Results showed that 83% of children in this study chose a color overlay. These students read significantly faster with their chosen overlay than with the random or no overlay (mean words per minute: no overlay 112.7, chosen overlay 116.8, and random overlay 115.25). They also read faster with the random overlay as compared to no overlay. Twenty-seven children chose a grey overlay and demonstrated no significant difference in reading rate with or without the overlay. After 5 months, there was a trend in the amount of usage of the overlays. Subjects given their chosen overlay were more likely to continue to use it than those given a random overlay, or a grey overlay. Again, they concluded that children who report symptoms and choose an overlay showed the most benefit from its use and this benefit was stable over time. These children did not differ in their use of a phonological reading strategy from those who did not choose an overlay.

In the last study, authors attempted to replicate findings in the previous studies with a larger sampling in order to better estimate the number of children who would benefit from overlay usage. Twenty schools volunteered to participate following a lecture given to teachers in the district. Twelve of these schools completed the study. Students ranged in age from 6 years 10 months to 8 years 6 months. The Teacher's Assessment Pack of the Intuitive Overlays was supplied to teachers who assessed students in the autumn of the year. Teachers were asked to give their opinion about the student's reading skill and whether or not the student had difficulty concentrating. Students were shown a stimulus page and asked questions about what they saw. Overlays were then identified using the above described method. Subjects who choose an overlay were then administered the Rate of Reading Test (four forms) with, without, without, and then with the chosen overlay. These subjects were also given the overlay free of charge to use when they wished. Teachers were told not to pressure students to use the overlays. Teachers were contacted nine months later to report which students were still using the overlays.

Results of this study showed that 60% of the 426 children chose a color overlay. These children read faster with their chosen overlay than with no overlay (test 1 with=73.64(20.5), test 2 without=71.63(22.48), test 3 without=71.83(22.3), test 4 with=75.23(21.1)). Eight months later, 52% of these children were still using the overlay. These children did not differ from other children who did not continue to use the overlay in the particular symptoms reported during screening. However, they did differ in their reported symptoms from children who did not choose an overlay. These children were also more likely to be reported by their teachers as having difficulty concentrating. Based on these results, they concluded that the children who report the most symptoms and who find overlays reduce or alleviate these symptoms tend to reap the most benefits from use of the overlays and these benefits appear to be stable over time.

O'Connor, Sofo, Kendall and Olsen (1990) investigated the effects of colored filters on reading rate, accuracy, and comprehension in a sample of school children aged 8-12. Children were screened with the IDPS (Irlen Differential Perceptual Schedule) (Irlen, 1983) and determined to be scoptopic or non-scoptopic. There is no available reliability or validity data available for this instrument. The Scoptopic group (n=67) was further divided and randomly placed into four groups: optimum overlay (n=17), clear overlay (n=17), random overlay (n=17), clear overlay with no pretest (n=16). The non-scoptopic group was randomly placed into two groups: clear overlay (n=12) and random overlay (n=13). Groups were pre and post tested a week apart using the Neale Analysis of Reading Ability (Neale, 1958) and Formal Reading Inventory (Wiederholt, 1986). One group from the scoptopic sample was only post tested to control for possible testing effects. Each student was given an overlay to use for one week for all reading tasks including math and told, “We think this might make reading a little easier for you.” Results indicate significant improvement in reading rate, accuracy, and comprehension for children with scoptopic sensitivity given the optimum overlay.   All other groups had mixed results with some children showing no change, and others showing small improvements or regressions in reading performance. They concluded that results from this study indicate that color overlays provide improvements to those with scoptopic sensitivity syndrome and that these changes cannot be attributed to motivational changes. According to these researchers, if improvement with color overlays is due to motivation (children expect they will do better with the overlays) positive changes should have also occurred in children in the scoptopic group given the wrong color, as well as in children in the non scoptopic group given color overlays.

Critiques of IS Research

Solan (1990), and Hoyt (1990) criticized several studies on Irlen Syndrome. First, in regards to the prevalence of scotopic sensitivity syndrome, Solan (1990) criticized O’Connner et al.’s (1990) report of more symptoms in poor readers than in good readers as evidence of higher incidence of IS. Instead, Solan claims that because these subjects did not undergo vision examination, that these numbers could be due to optometric problems rather than Irlen Syndrome as purported in Blaskey et al (1990). Hoyt (1990) states that because scoptopic sensitivity syndrome is not medically recognized, it is “an absolute necessity for any patient enrolled in an Irlen lens trial study to have a complete optometric or ophthalmologic examination at the time of enrollment into the study.”   Both Solan (1990) and Hoyt (1990) also criticized O’Conner et al. (1990) for possibly biasing their sample by using teachers who had attended an information session about scoptopic sensitivity prior to nominating students for the study. Further, Solan

(1990) criticizes the use the Neal Analysis of Reading Ability because it reports age scores that are difficult to interpret. He concluded that the present research was insufficient to identify IS as a separate syndrome nor color overlays or filters as permanent treatment of symptoms. Hoyt (1990) questioned the results that showed large numbers of subjects identified with scoptopic sensitivity regressed with the use of a clear overlay and stated, “We must conclude that testing parameters are so pernicious that validation may be nearly impossible.” Additionally, improvements reported in subjects given the clear overlay give credence to the argument of placebo effects. Finally, Hoyt (1990) criticizes O’Conner et al (1990) for their method of using 6 groups which yield small sample sizes in each group.

Hoyt (1990) and Solan (1990) also critique a study by Robinson & Conway (1990). This study suffered from many of the same flaws identified in the O’Conner et al. study. According to both Hoyt (1990) and Solan (1990) these researchers failed to ensure adequate optometric screening of subjects and lacked a control group. Hoyt (1990) additionally points out that even though researchers in both studies utilized the same reading measure, they obtained different results.

Even though research has not provided a strong basis for its use, the Irlen method (diagnosis of IS and use of color overlays and filters) has grown in popularity. Over 4,000 school districts use the Irlen Method. Clinics are located in 22 states in the U.S. and in several countries all over the world. Additionally, many organizations recognize the Irlen Method and fund diagnosis and treatment of Irlen Syndrome. Bills have been passed or are pending in Arizona, California and Massachusetts allowing use of the Irlen Method, and the Irlen Syndrome is recognized as a learning disability in the state of Alabama (Irlen, 2001).

One major criticism of the Irlen method is that effects are determined largely through self-report methods. Although Helen Irlen contends that IS is a problem of perception rather than a vision problem, measurements of eye movement during reading may provide another level of measurement of one's visual perceptual experiences. Research on eye movements during reading has provided a basis for understanding and measuring reading efficiency (Rayner, 1998) and is likely to yield important information in the area of visual perception as well.

Eye Movement in Reading

Over the past century, eye movement studies have shed light on what happens with the eyes during reading. It was previously believed that a good reader's eyes move smoothly across the page. However, research has found that movements are not smooth, but rather are broken. During reading, the eyes jump from point to point. These movements, termed saccades and fixations, occur so rapidly (milliseconds) that they are imperceptible. However, through the use of instrumentation, these movements can be captured and measured. Development of research in the area of eye movements has created a base for comparison of differences between and within subjects in the area of reading. Basic eye movements are described as saccades, fixations, and regressions. Saccades are high velocity movements of the eyes during which time no information is being processed. The purpose of saccades is to move the eye to the next point in which text can be brought into view and processed. Fixations occur between saccades during which time the eyes are still and are processing information in the fields of view. Regressions are backward saccades and can be short (a few letter spaces to correct for saccades that are too long) or long (greater than 10 letter spaces along the same line or to other lines that occur when the reader needs to reread text for comprehension) (Rayner, 1998). Data collected through eye movement studies have provided mean values of saccades and fixation measurements in silent and oral reading, visual research, scene perception, and typing (Rayner, 1998). A study by Fletcher and Martinez (1994) examined changes in eye movements with the use of color overlays (Fletcher & Martinez, 1994). In their study, subjects were screened with the IDPS to determine scoptopic sensitivity, as well as given the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981) or the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974) to estimate intelligence, and the Wide Range Achievement Test-Revised (WRAT-R). (Jastak & Wilkinson, 1984). Subjects of average intelligence, who met criteria for scoptopic sensitivity syndrome and who had at least fourth-grade decoding skills were included in the study (n=22). Subjects chose overlays that they identified as best reducing their symptoms. They were then asked to read a passage for five minutes to induce symptoms. Subjects were stabilized on the eye tracking equipment and shown a set of 10 randomly ordered paragraphs under the first condition (either with or without the overlay) and then shown another set of 10 in the opposite condition. Subjects read only the middle sentence in each passage. Each paragraph was followed by a multiple choice question. Data was analyzed with an ANOVA statistic. They stated that overall, results generally support the hypothesis that use of the color overlays improves parsing. Specifically, fixation counts and duration were significantly improved with subjects demonstrating fewer number of fixations (F=4.241, p=0.040) and shorter fixation durations (F=5.075, p=0.025) with the use of the overlay. These results indicate subjects had more automatic parsing when they read with an overlay verses when they read without it. There was also a significant reduction the number of regressions (F=5.024, p=0.026) and length of regressions (F=6.726, p=0.010) indicating that subjects had fewer misunderstandings that required correction of eye movements when they read with an overlay.

There were no significant differences in the number of saccades (F=1.578, p=0.210) and saccade lengths (F=2.228, p=0.136). There was also no significant difference in comprehension with use of the overlay (F=0.144, p=0.706). Descriptive statistics were not reported. It is possible that differences in comprehension were not observed because the amount of information that subjects read (one sentence per paragraph) was insufficient to ascertain the effects of IS on comprehension.

Fluency in Reading

One of the hallmarks of a good reader is the ability to read fluently. Fluent readers read with speed, accuracy, and proper expression. Their reading sounds natural and allows for understanding text. The ability to read fluently facilitates comprehension because text can be read automatically, allowing for resources to be used in the task of comprehension. Shaywitz (2003) describes fluency as the bridge to comprehension. For this study, fluency will be measured using oral reading fluency (ORF) which is a curriculum-based measure of speed and accuracy and has been shown to be sensitive to change, and predictive of overall reading ability (Shinn, 1989). These measures are quick (one minute) and easy to administer and have been demonstrated to be reliable and valid (Shinn, 1989).

One major criticism of the Irlen method is that improvement is determined predominately by subject report. Use of eye movement technology may prove to be very useful in providing an additional measure of the immediate effects of color overlays. Previous research using eye measurements reported improved parsing with the use of color overlays (Fletcher & Martinez, 1994). In that study, subjects showed a reduced number of fixations and regressions and decreased fixation durations with the use of optimum overlays.

Current Investigation

The purpose of this study is to further examine the immediate effects of the use of color overlays on reading efficiency as measured by an eye movement data recording system and oral reading fluency. The question to be answered is whether the use of color overlays improves reading efficiency.

People who suffer from IS report experiencing perceptual distortions and movements of the text. It is hypothesized that these experiences will be reflected in their eye movements. Those diagnosed with IS should exhibit longer fixation durations, more regressions, and shorter saccade lengths than those not diagnosed with IS. The null hypothesis is that there is no difference in eye movements between those diagnosed with IS and those not diagnosed with IS. This hypothesis could not be tested because of the 26 participants in the study, 24 met criteria for IS. Therefore, there were not enough participants who did not meet criteria for IS to provide a comparison group. This will be discussed later.

It is also hypothesized that subjects who no longer have to struggle to keep text stable will show improvement in their eye movements. Therefore, there should be differences observed in eye movements with the use of an optimal overlay, a random overlay, and a clear overlay. The null hypothesis is there is no difference in eye movements between conditions—optimum overlay, random overlay, clear overlay. The alternative hypothesis is that there is improved efficiency in eye movements in the optimum overlay condition as compared to the random and clear overlay conditions. The following hypotheses were tested for each eye movement measure:

H_o1: There are no differences in the number of eye fixations when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a1: Participants will show a fewer number of eye fixations when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

H_o2: There are no differences in the duration of eye fixations when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a2: Participants will show a shorter eye fixation duration when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

H_o3: There are no differences in the number of saccades when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a3: Participants will show a fewer number of saccades when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

H_o4: There are no differences in the length of saccades when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a4: Participants will have shorter saccades lengths when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

H_o5: There are no differences in the number of regressions when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a5: Participants will show a fewer number of regressions when they read with an optimal overlay, versus a random overlay, or with a Clear overlay.

H_o6: There are no differences in the length of regressions when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a6: Participants will show shorter regression lengths when they read with an optimum overlay, versus a random overlay, or with a clear overlay.

Improvement in visual perception should also affect reading fluency. It was originally hypothesized that participants would read faster and have fewer errors as measured by oral reading fluency. Because oral reading fluency data was not collected for several of the participants, this hypothesis was not tested as stated. Instead, during the study, reading time was measured through the eye tracking apparatus. Participants were asked to read 18 passages and data was collected on the amount of time they spent reading each one of them. This data was used in the study as a measure of reading fluency. The following hypothesis was tested:

$H_0$7: There are no differences in the reading time when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a7: Participants will show a shorter reading time when they read with an optimum overlay, versus a random overlay, or with a clear overlay.

CHAPTER 2

METHODS

A repeated measures design was used to assess differences in eye movements when participants read with a clear overlay, their optimum overlay, and random overlay.

Participants

An *a priori* power analysis was conducted. For alpha = .05, effect size = .25 and power = .8 requires n = 28. Participants in this study were 24 people (2 males and 22 females) recruited from a pool of undergraduate psychology students (18) at a large university in the northeastern United States as well as in from the surrounding community (6). They ranged in age from 17 to 57 with a mean age of 22 (1.7). Students earned academic credit as outlined in the departmental policy for research participation. Community participants received $22 for participation in the study (see Appendix A).

Subjects were provided with information regarding the study, any risks that they may incur, confidentiality procedures, and their rights of participation. After insuring subjects understood their rights, they were asked to sign a consent form (Appendix A). This study was reviewed and approved by the School of Education and the Psychology Department Institutional Review Boards.

Materials

Irlen Reading Perceptual Scale (IRPS)

Subjects were screened for scotopic sensitivity syndrome (Irlen Syndrome) with the Irlen Reading Perceptual Scale (Irlen, 2003). The Irlen Institute states that this instrument requires specialized training to administer and use of the materials are restricted to certified Irlen screeners (Irlen, 2003). With the permission of Helen Irlen, this researcher was trained at a certified Irlen Screeners two-day training for the purpose of this study and administered all screening.

The IRPS consists of three components. The first is a questionnaire used to gather information from subjects regarding symptoms they may experience and compensatory strategies they employ to ease these symptoms. Subjects are asked to recall their experiences for those times when reading becomes uncomfortable and when they feel as though they want to stop reading. Reading difficulties include skipping lines and losing one's place in text during reading while somatic symptoms range from red watery eyes to headaches and nausea. Compensatory strategies that may be used to manage these problems include using one's finger as a marker when they read, taking frequent breaks, rubbing eyes, blinking often and reading in dim lighting conditions (Irlen, 2003). For each question, participants indicate the degree to which they experience the problem by responding often, sometimes, never, or don't know. For example, respondents were asked, "Do you unintentionally read words from lines above or below?" and "Do you get a headache." Irlen (2003) states that because proficient readers rarely engage in reading compensatory behaviors, scores yielded from answers on this questionnaire identifies people suffering from IS and to what degree from slight to moderate.

The second component of the screening involves the use of perceptual tasks designed to elicit symptoms of IS quickly or more intensely. Screening was administered under layout and lighting conditions as prescribed in the training manual. There are seven tasks. However, Irlen (2003) states that there is no particular task that will elicit symptoms in everyone with IS. Therefore, the number and particular tasks administered will depend upon how quickly symptoms appear. Irlen (2003) states that the tasks are designed to elicit each individual's unique set of misperceptions and gives subjects a language with which to talk about them. The tasks involve the use of high-contrast black figures on which backgrounds which subjects are asked to look at and answer questions about what they see happening and perform such tasks as counting symbols or lines in the figure. The tasks are not designed for subjects to give a right or wrong answer; rather, subjects are asked to report what happens during the task. In addition, the examiner observes and records subject's body language for signs of discomfort or adjustment such as head movements, excessive blinking, narrowing or widening of the eyes, and any comments the subject makes regarding their experience. According to Irlen (2003), people without IS have a preferences for reading black text on white paper even under florescent lighting conditions; however, for those who suffer form IS, these normal reading conditions stress the visual system and cause perceptual distortions (Irlen, 2003). Thus, these tasks serve the purpose of validating the diagnosis of IS.

The third component of the screening involves use of the color overlays. The overlays consist of transparent color plastic sheets with colors ranging from yellow to blue-gray. A total of 10 overlays are presented to subjects to determine color preference. Subjects are shown a page of text written in Dutch and asked to read letters in a line of text. The use of Dutch eliminates prediction of text that occurs during reading and allows subjects to focus on and report their visual perceptual experience. The examiner then places an overlay over half the page and asks the subject if symptoms appear better or worse with or without the overlay. Each overly is presented in like manner, and repeated with two or more overlays at a time until the optimum overlay or combination is identified. After the subject chooses their preferred overlay(s), the preference for glossy verse mat finish is determined. Perceptual tasks that elicited symptoms for the subject can then be repeated with the chosen overlay to see if the subject's experience is improved. The overlays are purported to reduce or eliminate the perceptual distortions and are the last step in screening to validate the presence of IS. According to Irlen (2003), those without IS see no difference with the use of color overlays and will prefer no color to color. There is no published peer-reviewed reliability and validity data for this instrument.

Reading Fluency

Irlen (2003) states, "Changes in reading flow, fluency, or accuracy can be observed during the screening since symptoms disappear with the correct colour" (p. 35). Changes in fluency will be measured with both silent and oral reading. Changes in silent reading fluency will be measured using eye measurement technology (discussed below). To examine changes in oral reading fluency, subjects were administered Curriculum-Based Measurement Oral Reading Fluency measures. Oral reading fluency is a curriculum-based measure that has been demonstrated to be a good indicator of reading efficiency (Shinn, 1989). Validity studies of CBM one-minute reading measures reported correlation coefficients ranging from .73 to .91 with criterion tests of reading (Marston, 1989). Scorers administered these measures using standardized directions which asked participants to read aloud passages of text for one minute (Shinn,1989).

Reading Passages

Passages of text were used for both eye measurement reading tasks and the oral reading fluency measure. Passages were obtained from various aptitude preparation manuals and were controlled for difficulty using the OKAPI! On-line system for creating curriculum-based assessment problems using the Dale-Chall readiblity formula (Wright, 2007). Passages with difficultly ratings of 11^{th} – 12^{th} grade were used. Methods for probe creation and administration were followed as prescribed by Shinn (1989).

Eye Tracking

Eye movement data was collected using the Eyelink II video-based eye tracking system. This system consists of a padded headband mounted with three miniature cameras that track pupil and corneal reflections and record eye movement data into a PC computer for analysis. The system is reported to be accurate with a less than .05° average gaze position error rate (SR Research, 2007). Subjects were presented with passages of text on a computer screen and asked to read aloud for one minute. Data was collected for eye movement measures (fixations, saccades, regressions) as well as the amount of time it took to read the passage.

Independent Variables

The independent variables for this study are the color overlays. Three conditions were used—a clear overlay, optimum overlay(s), and random overlay(s)—which are determine individually through the IRPS screening process described above.

Dependent Variables

Dependent variables include eye-tracking measures--fixations, saccades, and regressions—reading time, and oral reading fluency measures.

Analysis

This research will examine the differences in eye movement and oral reading performance between conditions—clear overlay, optimum overlay, and random overlay. Data was data will be analyzed using a MANOVA statistic.

Data Collectors

Two graduate students enrolled in a school psychology program were used as data collectors and scorers/raters. They were trained in the use of the eye measurement apparatus by researchers in the eye laboratory, and practiced until they were proficient in the use of the apparatus. These students were naïve to the optimum and random conditions. They had been previously trained in the administration of oral reading fluency passages.

Procedure

Participants in the study were undergraduate students recruited through the human subjects pool of the psychology department as well as several subjects who were recruited from the surrounding community. Data collection took place over two sessions. In the first session, volunteers were asked to participate in a study about the effect of color in reading. and were provided with information regarding the study, risks involved, and rights of participation and will be asked to sign a consent form (Appendix A). Volunteers who agree to participate in the study completed a questionnaire regarding demographic information, reading histories and experiences, and knowledge of Irlen Syndrome/Scotopic Sensitivity Syndrome and or use of color overlays or filters in reading (Appendix A), and were then screened for scoptopic sensitivity syndrome/Irlen Syndrome with the Irlen Reading Perceptual Scale (IRPS). In the original design of this study, subjects were to be placed into one of two groups based on the results of this screening—Irlen+ or Irlen-. However, during screening it became apparent that that most subjects met criteria for IS. Therefore, a comparison group could not be created.

In the second session, subjects reported to the eye tracking lab and were given a paper back copy of *The Complete Short Stories of Mark Twain* to read for five minutes to induce symptoms of scoptopic sensitivity (Fletcher & Martinez, 1994). They were then asked to read aloud from three passages for one minute each while they were audio recorded. Each passage was read under one of the three conditions—with a clear overlay, with an optimum overlay, and with a random overlay. The experimenter followed along, marking errors and recording the one-minute mark in the text. The experimenter then read a brief description of the eye measurement procedures and fitted subject with the headband apparatus following procedures for safety and hygiene. Subjects sat in front of a computer monitor while the experimenter went through the initial calibration procedure which last approximately one to two minutes. After calibration, subjects were presented with a passage of text consisting of black type on a white background, double-spaced in times new roman size 10 font. Subjects were asked to read the passage silently and then answer multiple choice questions. A total of 18 passages were read under the three conditions--clear overlay, optimum overlay, and random overlay (6 pages in each condition). The order of presentation was randomized to control for possible order effects. At the end of the session, subjects were debriefed information through a short questionnaire to assess subject's experience in the study and perceived usefulness of the overlays (Appendix A).

CHAPTER 3

RESULTS

This chapter will present the descriptive statistics (means and standard deviations) for dependent measures (eyetracking indices), and an analysis of each measure under three conditions: clear overlay, optimum overlay and random overlay conditions.

Each subject completed a short questionnaire and was screened with the Irlen Reading Perceptual Scale (IRPS). The purpose of this scale is to understand one's reading history and experience, elicit symptoms of IS through various perceptual tasks, and to select color overlays that alleviate the distortions. This information is then used to initially diagnose IS. The following were results of the questionnaire and IRPS.

Questionnaire

According to Irlen, people who suffer from Irlen Syndrome will typically read less for pleasure as reading is uncomfortable. They may also prefer to read in low lighting conditions. Participants in this study were asked how many hours they spend engaged in reading activities per week as well as under what kind of lighting conditions they prefer to read. They reported a wide range of hours spent each week reading for pleasure (0-22). Some reported not reading for pleasure at all, while others reported reading as many as 22 hours per week for pleasure. On average, participants read 4.13 (4.93) hours per week for pleasure. Participants reported spending more time reading for work or school. On average they read 9.58 (8.05) hours per week with a range of 0-30 hours (see in Appendix F). Most participants reported preferring bright lighting conditions (14). Five (5) reported preferring medium lighting conditions and four (4) reported preferring dim lighting conditions. One (1) participant indicated no preference of lighting conditions (see Table 2 in Appendix B). When asked whether they have a history of reading problems, one (1) participant reported having diagnosis of a specific reading disability. None of the participants had neither heard of IS prior to the study nor had ever been prescribed overlays for reading or undergone vision training. The average number of months since their last eye exam was 20.17 (26.76). Eleven participants reported having normal uncorrected vision, 10 wore contact lenses, two (2) reported occasionally wearing reading glasses, and one (1) reported wearing glasses for distance (see Table 3 in Appendix B).

Irlen Screening

Twenty-six participants were screened with the Irlen Reading Perception Scale (IRPS) and placed into one of four IRPS diagnostic categories based on the number of symptoms they experience during visual tasks and the amount of improvement they report with the color overlay. Ten participants were identified as Excellent Candidates, seven (7) were identified as Good Candidates, seven (7) as Possible Candidates and two (2) were Non-candidates. For purposes of this study, data from the two non-candidates were not included in the analysis (see table 4 in appendix B). Participants chose a color overlay or combination of overlay(s) that they believed alleviated distortions or improved reading comfort. Most participants (12) chose one overlay. However, 10 participants chose a combination of two overlays, and two (2) participants chose three overlays. Darker colors were most often preferred (see Table 5 in Appendix B). The most commonly chosen color overlay was blue-gray (11) followed by turquoise (7) and then purple (6) (see Table 6 in Appendix B).

Eye Tracking Measures

Participants were asked to read text on a computer screen under three conditions—clear overlay, optimum overlay and random overlay—while their eye movements were tracked. Data was then averaged for each subject under each condition. A multivariate analysis of variance (MANOVA) was used to analyze each dependent variable for differences between conditions. This statistic was chosen because the data yielded many dependent variables. The Dunn-Bonferroni procedure was used to control the Type I error for each of the family of dependent variables (Fixations, Saccades, and Regressions). The Fisher LSD procedure was used to control the familywise error rate for each of the multiple comparisons within the univariate analyses. Effect sizes were calculated with a pooled standard deviation using Cohen's d (Cohen, 1998).

Fixations

Fixations are the points in the text where the eyes rest and process information. Studies have suggested that poor readers make more fixations than do normal readers (Rayner, 1998). The hypotheses being tested are:

H_o1: There are no differences in the number of eye fixations when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a1: Participants will show a fewer number of eye fixations when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

The omnibus *F* indicated that there were differences in the number of fixations when participants read with a clear, an optimum, or a random overlay(s) and these differences were statistically significant (F=5.34, p=.013) (see Table 1). Post hoc contrasts indicate a significant difference between the clear and optimum conditions (t=-2.87, p=.009) with a medium effect size (ES) of .6. There was also a significant difference between the optimum and random conditions (t=2.73, p=.012) with a small ES of .4. Differences between the clear and random condition were not significant (t=-1.02, p=.318). Given these results, the null hypothesis is rejected, indicating that participant's had more fixations with their chosen (optimum) overlay, than with a random or clear overlay(s). These results are contrary to what would be predicted by Irlen.

Table 1: Mean Scores and Standard Deviations for Number of Fixations

	Clear Overlay	**Optimum Overlay**	**Random Overlay**
Mean (SD)	85.82 (17.81)	96.78 (18.16)	89.55 (16.86)

Fixation Duration

Poor readers make longer fixations than do good readers. (Rayner, 1998). It should follow that people with IS should show shorter fixation durations when reading under the corrected condition (optimum overlay) than in the uncorrected conditions (clear or random). The hypotheses being tested are:

H_o2: There are no differences in the duration of eye fixations when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a2: Participants will show a shorter eye fixation duration when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

The omnibus F indicated that there were significant differences in fixation duration between the conditions. On average, participants fixated longer when reading with their chosen (optimum) overlay then they did with a random overlay or with a clear overlay (see table 2). Analysis of this data indicate that these differences were statistically significant (F=7.58, p=.003). Post hoc contrasts indicated a significant difference between the clear overlay and the optimum overlay conditions (t=-3.36, p=.001) with a medium ES of .6; as well as between the clear overlay and random overlay conditions (*t*=-3.74, *p*=.001,) medium ES of .6. There was no significant difference between the optimum overlay and random overlay conditions. Thus, the null hypothesis in this case would be rejected. As was the case with the number of fixations, these results to do not support improvement with the use of the color overlays.

Table 2: Mean Scores and Standard Deviations for Fixation Duration

	Clear Overlay	Optimum Overlay	Random Overlay
Mean (SD)	236.46 (21.77)	252.73 (29.20)	247.81 (23.36)

Saccades

Saccades are the rapid movement of the eyes across the text. The purpose of saccades is to move the eyes to the optimal viewing position where new text can be processed most efficiently (quickly). When the eyes land in an area other than the optimal position, refixations may occur where the eyes must then adjust to another position to process the word, and this can result in longer processing times (Rayner, 1998). Poor readers tend to have shorter saccades. It is reasonable to predict that these readers would also have a higher number of saccades. The hypotheses being tested are:

H_o3: There are no differences in the number of saccades when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a3: Participants will show a fewer number of saccades when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

The omnibus *F* indicated there were significant differences in the number of saccades participants made under each condition. On average, participants had more saccades when they read with their optimum overlay(s) versus reading with a clear overlay or a random overlay (see

Table 3). Analysis of these differences indicate that they are statistically significant (*F*=5.22, *p*=.014). Post hoc analysis showed significant differences between the clear condition and the optimum condition (*t*=-2.74, *p*=.011) medium ES of .6, as well as between the optimum condition and the random condition (*t*=2.81, *p*=.010) small ES of .4. Differences between the clear and the random conditions were not significant (*t*=-.949, *p*=.352). Given these results, the null hypothesis would be rejected. Contrary to what would be predicted by Irlen, these participants did not show improvement in saccadic eye movements with the use of the color overlays.

Table 3: Mean Scores and Standard Deviations for Number of Saccades

	Clear	**Optimum**	**Random**
Mean (SD)	67.97 (16.54)	77.64 (16.85)	71.12 (15.93)

Saccade Length

Saccades occur when the eyes move rapidly across text to land at a position where information can be processed most efficiently. As text becomes more difficult to read, saccade length decreases (Rayner, 1998). It is reasonable to predict that participants will have longer saccade lengths when they read with their optimum overlay versus a clear or a random overlay. The hypotheses being tested are:

H_o4: There are no differences in the length of saccades when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a4: Participants will have shorter saccades lengths when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

Participants had shorter saccades when they read with their optimum overlay(s) verses a clear overlay or a random overlay(s) (see Table 4). However, these differences were not shown to be statistically significant (F = .406, p = .671). Thus, in this case we failed to reject the null hypothesis. Again, participants in this study did not show improvement with the use of their chosen color overlay as was predicted by Irlen.

Table 4: Mean Scores and Standard Deviations for Saccade Length (letter spaces)

	Clear	**Optimum**	**Random**
Mean (SD)	12.26 (1.82)	12.01 (1.88)	12.20 (1.53)

Regressions

Regressions are saccades where the eyes move backward in the text. Poor readers tend to make more regressions than do good readers (Rayner, 1998). It should be predicted that participants will have fewer regressions with the optimal overlay than without a clear overlay or a random overlay. The hypotheses being tested are:

H_o5: There are no differences in the number of regressions when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a5: Participants will show a fewer number of regressions when they read with an optimal overlay, versus a random overlay, or with a clear overlay.

The Omnibus *F* indicated significant differences in the number of regressions under each condition (F = 5.05, p = .016). Participants had the fewest number of regressions when they read with a random overlay, as compared to when they read with a clear overlay or their optimum overlay(s) (see Table 5). Post hoc tests show that the differences between the clear condition and the optimum condition were not statistically significant (t=-1.52, p=.142). Differences between the Clear condition and the random condition were also not significant (t=1.15, p=2.63). However, there was a statistically significant difference between the optimum and random conditions (t=2.87, p=.009) small ES (d=.3). Here, the null hypothesis is rejected. Participants did not show predicted improvement with the use of the optimum overlay. However, they did show a small improvement with the use of the random overlay over the clear or chosen overlay. This result would be contrary to that which IS would predict.

Table 5: Mean Scores and Standard Deviations for Number of Regressions

	Clear	**Optimum**	**Random**
Mean (SD)	22.35 (10.94)	23.66 (10.03)	20.86 (9.06)

Regression Length

Readers may regress a few letter spaces to correct for overshooting the targeted text, or they may regress further back in the text when they fail to comprehend what was read. Good readers show more accuracy in moving to the point in text that caused the difficulty, whereas poor readers tend to back track more through the text (Rayner, 1998). It should be predicted that participants will have shorter regression lengths when they read with their chosen overlay versus a clear or random overlay. The hypotheses to be tested are:

H_o6: There are no differences in the length of regressions when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a6: Participants will show shorter regression lengths when they read with an optimum overlay, versus a random overlay, or with a clear overlay.

The omnibus *F* indicated differences in regression lengths between conditions were not statistically significant (F=.817, p=.455). Participants regressed farther in text when reading with their optimum overlay(s) than with a clear overlay or a random overlay(s) (see Table 6). As such, the null hypothesis is not rejected and is contrary to what IS would predict.

Table 6: Means and Standard Deviations for Regression Length (letter spaces)

	Clear	Optimum	Random
Mean (SD)	7.51 (4.08)	7.64 (2.77)	6.99 (2.50)

Reading Time

Data from eye tracking measures yielded a reading time reporting the amount of time that participants took to read passages under each condition. It would be expected that participants should take less time to read passages when reading with their optimum overlay. The hypotheses to be tested are:

$H_0$7: There are no differences in the reading time when participants read with an optimal overlay, a random overlay, or with a clear overlay.

H_a7: Participants will show a shorter reading time when they read with an optimum overlay, versus a random overlay, or with a clear overlay.

The omnibus F indicated that there were no significant differences between conditions (F=1.51, p=.241). Participants read fastest under the random overlay condition and slowest in the optimum overlay condition (see Table 7). These participants did not see improvement in how fast they read when they used their optimum overlay.

Table 7: Means and Standard Deviations for Reading Time (Milliseconds)

	Clear Overlay	Optimum Overlay	Random Overlay
Mean(SD)	56094.78 (20417.86)	60815.40 (15552.48)	55968.32 (18767.97)

CHAPTER 4

DISCUSSION

First, this chapter will summarize the results of the current study. Second, the limitations of this study will be discussed. Finally, future research questions and implications for use of color overlays will be discussed.

Results Summary

The current study examined immediate effects of use of color overlays by looking at differences in eye movements during reading under three conditions, with a clear overlay, a random overlay(s), or an optimum overlay(s). One major criticism of the Irlen method is that improvement has been determined largely through subjective measures such as self-report. The present study used eye tracking technology as a more objective measure of differences when subjects used color overlays.

Results showed variations in participants' reading efficiency as measured by eye tracking measures (i.e. fixation, fixation duration, saccades, saccade length, and regressions). Participants had more fixation and shorter fixation times when they read with a clear overlay as compared to reading with their optimum overlay(s) or a random overlay(s) (Tables 8 and 9). In addition, they had significantly more saccades when they read with an optimum overlay versus with a random or clear overlay (Table 10) indicating that participants were able to process text more efficiently with a clear overlay. There were no significant differences in the length of saccades in each condition (Table 11).

Participants in this study showed the fewest number of regressions when they read with a random overlay versus with their optimum or a clear overlay (Table 12). The difference was statistically significant between the optimum and the random conditions for this measure; however, the effect size was small (*d=.3*). In addition, regressions of a few character spaces, to up to a full line of text indicate a correction for understanding. There was no significance in the length of regressions in text between conditions (Table 13).

As mentioned earlier, because oral reading fluency data was not collected for several participants, fluency was determined by reading time data collected from the eye tracking apparatus. Results showed no significant difference in the amount of time participants took to read passages under each condition described above (Table 14). This finding indicates that there was no increase in reading fluency with the use of the color overlays. This finding appears to correlate with findings from Blaskey et al. (1990) who found no differences in rate of reading with use of color overlays.

Discussion

Several studies have that reported positive effects of the overlays on reading (Blaskey et al., 1990; Evans, Cook, Richard & Drasdo, 1994; Tyrell, Holland, Dennis & Wilkins, 1995; Fletcher & Martinez, 1994; Robinson & Conway, 1990; Wilkins, Lewis Smith, Rowland & Tweedie, 2001). Fletcher and Martinez (1994) examined changes in eye movements with the use of color overlays and reported improvements in parsing with the use of chosen color overlays. The present study does not support those findings. In this study, significant differences were found when participants read with and without color overlays, indicating improved reading efficiency was variably found between the clear and the random conditions. That is, participants tended to show improvements in eye movements when they read with a clear or random overlay versus an optimum overlay. One explanation for this finding might be that the subjects in this study despite meeting the criteria for IS, did not report a reading problem or a reading disability. However, previous studies indicated that participants with a history of reading difficulties benefit most for the use of the color overlays. Irlen (2005) stated that IS is a major factor that contributes to those who struggle to learn to read. She reported that as many as 46% of people diagnosed with learning disabilities have IS. Tyrell et al. (1995) found improvement with the use of color overlays for participants who met criteria for IS and had average, below average, and well-below average reading ability. In the present study, only one person reported reading problems and had a diagnosis of a reading disability. (However, even for this person, there was varied performance on the eye tracking measures with improvement seen in some measures with the optimum overlay, and not in others). Participants reading skills were not assessed in the present study. Participants were college undergraduates and community members who might have a reading ability that falls within the average range and have developed effective strategies that seem to overcome the perceptual distractions and discomfort. It is interesting to note that most of the participants fell within the excellent, good, and possible candidate diagnostic categories on the IRPS, indicating that they all experience some kind of discomfort or distortions during reading and that they felt the overlays moderately or significantly improved their experience. It may be that these distortions were not severe enough in these participants to affect reading efficiency or there is something about the IRPS as an instrument that is not valid and reliable to discriminate who meets or does not meet the IRPS criteria.

Based on the above findings, there are major criticisms that can be made about the Irlen method. The first concerns the diagnosis of IS using the Irlen Reading Perceptual Scale (IRPS). There are no reliability and validity data published for this instrument, and so it is difficult to know if the scale is measuring what it purports to measure or how reliable results are. Further, the process of diagnosis poses a problem of expectancy when evaluating the effectiveness of the color overlays. According to Irlen (2003), the IRPS is not intended to be administered as a standardized test instrument, but rather as a diagnostic tool and means of “educating the client” about their condition. Many of the studies cited in this research state that their methods were designed to reduce or eliminate results due to subject expectancy. However, the IRPS intentionally informs the subject about the premise of the study; and therefore creates the opportunity for results based on expectancy. For example, the initial questioning about symptoms experienced and compensatory strategies used during reading primes subjects about the problem of IS. Such questions as, “Does it take effort to stay on the words you are reading? Do you unintentionally skip words?” alert the subject to the proposed problem of IS. Subjects become more aware of the premise of IS during administration of the tasks. When given high contrast black and white figure and asked to count lines, spaces, or characters, subjects are then asked a series of specific questions about what they may see. The problem here is that the questions are so specific as to be suggestive. For example, when staring at a figure of a cube composed of lines and spaces, the examiner asks such questions as, “Do the lines rise up or stay flat? Do you see flashes of light?” Much like staring at optical illusions, subjects may try to “figure out” what they are supposed to see, and may report symptoms because they were suggested by the examiner. In the present study, all subjects reported seeing at least some of the suggested distortions. It would be interesting to see if questions were modified to be more general, what subjects would report seeing. The last component of the IRPS, is the selection of the color overlays. This process suggests to subjects that they should experience improvement with the use of the overlays. For example, when the overlays are presented over text and/or figures, the examiner asks the subject which color “is more comfortable” and “best stops the distortions". The examiner is instructed to place and remove overlays in such as way as to not let any of the white background show. When an optimum color is chosen, the overlay is placed over the page and the examiner asks if the page is too bright or uncomfortable. The overlay is then removed and the same question is asked. The overlay is then placed over half the page and specific questions about comfort, sharpness of text, brightness of the background, and spacing between letters and lines of text are asked. Again, this questioning seems so specific as to further convince the subject of the existence of a problem and introduces the idea that the color overlay will alleviate it.

Finally, the threshold for diagnosis appears quite low. According to the manual three areas of the test are used to determine the presence of IS. The first area refers to the scores obtained on the initial questions about reading difficulties and discomfort. There are 17 questions that describe reading difficulty and 17 questions that describe discomfort. Subjects respond, "never, sometimes, often, or don't know" for each item and points are given for answers of sometimes or often. Scores of 4 or more are considered moderate and score greater than 7 are considered severe. The second area considered in diagnosis is the appearance of symptoms on a white page, which is a page of text in Dutch. Subjects need only to report one symptom on this page to meet criteria in this area. The last consideration is the amount of improvement that subjects report on the white page with the use of the identified color overlay. The minimum requirement for subjects to be considered a possible candidate for IS is a moderate to high score on either the reading difficulty or reading discomfort questions, one symptom on the white page, and slight improvement with the use of the overlay. This low threshold for diagnosis would seem to identify high numbers of subjects who would be described as possibly suffering from IS. In the present study, 24 of 26 participants met at least these minimum criteria.

Limitations

The first limitation of this study was the number of participants who met criteria for IS. Because most participants met criteria for IS, it was not possible to create two groups (experimental and control) to evaluate differences in eye movements between those who have IS and those who do not. This difficulty illustrates the limitations of the IRPS as a valid instrument for the study in selection of subjects for this study. Only one participant in the study reported having a reading disability. Recruitment of subjects with a history of reading disabilities may have yielded different results as previous studies have shown these populations may benefit most from use the color overlays.

Computer versus Paper

A second limitation of this study was the use of a computer screen to measure eye tracking. Diagnosis of IS and selection of overlay(s) was conducted with text on paper, while eye tracking measures were conducted on a computer screen. Placement of the overlays was somewhat cumbersome. Although participants read under similar lighting conditions, there may have been some difference in effects of the overlays between light reflected on the paper and the light illuminated from computer screen. During debriefing, some participants indicated that reading text on the computer screen was more difficult than reading from paper. Further, because we were not able to collect oral reading fluency data from all subjects, we were not able to evaluate any differences that may have been seen when subjects read from paper versus the computer screen.

Vision Examination

The final limitation of this study involves vision screening. For practical reasons, participants in this study did not undergo the specific vision examination suggested by Blaskey et al. (1990). Most participants had received a regular eye-examination with the past 2 years. However, it is possible that symptoms reported were due to a vision disorder rather than IS.

Summary & Conclusions

The current study investigated the effect of color overlays on reading efficiency as measured by eye tracking. According to Irlen (2005), Irlen Syndrome is a visual perceptual condition that makes reading uncomfortable and affects reading efficiency and fluency. Color overlays or specially tinted glasses (filters) are claimed to alleviate symptoms of this condition. Several studies have been conducted on the effect of color overlays on reading and found positive results in reading fluency with the use of overlays (Tyrrell et al., 1995; Robinson & Conway, 2001; Wilkins et al., 2001; O'Connor, et al., 1990; Fletcher & Martinez, 1994). Blaskey et al. (2001) reported no improvement in reading fluency with the use of color overlays. The current study supports results from Blaskey et al. (2001).

Findings of the present study raise a number of questions about the use of the IRPS as a tool to diagnose Irlen Syndrome. Irlen (2005) stated that 12-14% of people in the general population may struggle with IS. In the current study, all but 2 participants met criteria for the syndrome. This finding suggests the IRPS instrument is not valid and reliable in assessing individuals who present with visual perception difficulties that affect reading. Given the growing popularity of the Irlen method and its use in schools as a reading intervention, there is a need for future research to determine the validity and reliability of the IRPS instrument in assessing visual perceptual difficulties that affect reading.

APPENDIX A

INFORMATION FOR PARTICIPANTS

The Effect of Color Overlays on Reading Efficiency
Rhonda Morrison
Doctoral Candidate, School Psychology
University of Massachusetts
413-546-3170, rfm@educ.umass.edu

Thank you for participating in this study. The premise of this research is to study the effect of using color overlays on reading efficiency. It is based upon the Irlen Method which proposes that some people who struggle with reading do so because they experience visual-perceptual distortions of text which make reading uncomfortable. Using the Irlen Reading Perceptual Scale (IRPS), subjects who report and are shown to have these difficulties are diagnosed with Scoptopic Sensitivity Syndrome or Irlen Syndrome (IS). According to the Irlen Method, using color overlays helps to alleviate these distortions making reading more comfortable. Previous research has reported improvements in subjects who use the overlays. However, improvement has been largely subjective and based upon self-reports. The current research seeks to measure differences in reading efficiency using eye movement technology. This technology provides measures of reading efficiency by examining eye movement behavior during reading. It is hypothesized that subjects will show more efficient eye movements during reading with the use of an optimal color overlay verses clear or random overlay.

If you would like to receive a summary of the findings of this research when it is completed, please contact Rhonda Morrison at rfm@educ.umass.edu. For information about the Irlen Method, please see www.Irlen.com.

If you would like further information, please contact the faculty advisor for this research, Dr. Adrian Staub in the Psychology Department, Tobin 430, 545-5925, astaub@psych.umass.edu. If you have any concerns about your rights as a participant in this study you may contact the Chair of the Psychology Department, Dr. Melinda Novak, at mnovak@psych.umass.edu, or call 413-545-2387; you may also contact the Human Research Protection Office via email (humansubjects@ora.umass.edu); telephone (413-545-3428); or mail (Office of Research Affairs, 108 Research Administration Building, University of Massachusetts, 70 Butterfield Terrace, Amherst, MA 01003-9242).

Thank you again for your participation.

Rhonda Morrison
Researcher
rfm@educ.umass.edu

APPENDIX B

QUESTIONNAIRE

The Effect of Color Overlays on Reading Efficiency – Questionnaire
(These questions were presented orally to participants)

Name: ____ **Date**: _____________

Age: _________ **Sex**: _________

1.	Do you have a history of reading problems?	
2.	Have you ever been diagnosed with a reading disability?	
3.	How much would you say that you read for pleasure each week? (# of hours)	
4.	How much would you say you read for work/school each week? (# of hours)	
5.	Under what kind of lighting conditions do you like to read?	
6.	Do you wear glasses or contact lenses?	
7.	When was the date of your last eye exam?	
8.	Have you ever heard of Irlen Syndrome or Scotopic Sensitivity Syndrome?	
9.	Have you ever been screened for Irlen Syndrome?	
10.	Have you ever had vision training?	
11.	Have you ever been prescribed color overlays for reading?	
12.	If yes, have you ever used color overlays for reading?	

Other comments:

APPENDIX C

DEBRIEFING FORM

The Effect of Color Overlays on Reading Efficiency
Rhonda Morrison
Doctoral Candidate, School Psychology
University of Massachusetts
413-546-3170, rfm@educ.umass.edu

Thank you for participating in this study. The premise of this research is to study the effect of using color overlays on reading efficiency. It is based upon the Irlen Method which proposes that some people who struggle with reading do so because they experience visual-perceptual distortions of text which make reading uncomfortable. Using the Irlen Reading Perceptual Scale (IRPS), subjects who report and are shown to have these difficulties are diagnosed with Scoptopic Sensitivity Syndrome or Irlen Syndrome (IS). According to the Irlen Method, using color overlays helps to alleviate these distortions making reading more comfortable. Previous research has reported improvements in subjects who use the overlays. However, improvement has been largely subjective and based upon self-reports. The current research seeks to measure differences in reading efficiency using eye movement technology. This technology provides measures of reading efficiency by examining eye movement behavior during reading. It is hypothesized that subjects will show more efficient eye movements during reading with the use of an optimal color overlay verses clear or random overlay.

If you would like to receive a summary of the findings of this research when it is completed, please contact Rhonda Morrison at rfm@educ.umass.edu. For information about the Irlen Method, please see www.Irlen.com.

If you would like further information, please contact the faculty advisor for this research, Dr. Adrian Staub in the Psychology Department, Tobin 430, 545-5925, astaub@psych.umass.edu. If you have any concerns about your rights as a participant in this study you may contact the Chair of the Psychology Department, Dr. Melinda Novak, at mnovak@psych.umass.edu, or call 413-545-2387; you may also contact the Human Research Protection Office via email (humansubjects@ora.umass.edu); telephone (413-545-3428); or mail (Office of Research Affairs, 108 Research Administration Building, University of Massachusetts, 70 Butterfield Terrace, Amherst, MA 01003-9242).

Thank you again for your participation.

Rhonda Morrison
Researcher
rfm@educ.umass.edu

APPENDIX D

CONSENT FORM – UNDERGRADUATES

Consent Form for Participation in a Research Study
University of Massachusetts Amherst

Principal Investigator: Rhonda Morrison
Study Title: The Effect of Color Overlays on Reading Efficiency

WHAT IS THIS FORM?

This form is called a Consent Form. It will give you information about the study so you can make an informed decision about participation in this research study.

WHO IS ELIGIBLE TO PARTICIPATE?

Undergraduate students of the University of Massachusetts psychology department who have normal, uncorrected vision or wear soft contact lenses are eligible to participate in this study.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this research project is to study the effect of the use of color overlays on reading efficiency as measured through oral reading rate and eye movements.

WHERE WILL THE STUDY TAKE PLACE AND HOW LONG WILL IT LAST?

The study will be conducted in the eye tracking laboratory and adjacent classrooms in Tobin Hall. The study will be conducted over two sessions which may or may not occur on the same day. The first session will last approximately 45 minutes, and the second session will last approximately 1 hour.

WHAT WILL I BE ASKED TO DO?

This experiment will take place over two sessions. At the first session, you will be screened for visual perception in reading. Based on the results of this screening, you may be asked to complete further reading tasks in the Eye Movement laboratory in Tobin Hall.

Session One - Screening: You will be given a questionnaire about your demographic information and reading history. You will then be given a reading and visual perceptual screening. The screening involves answering questions about your reading experiences, performing perceptual tasks with printed figures, and reading text through transparent color sheets. This session will last approximately 45 minutes.

Session Two – Reading and Eye Movement: The second session will take place in the eye movement laboratory in Tobin Hall. Upon arrival to the lab, you will be given text to read for approximately five minutes. You will then be audio taped as you read aloud passages with and without the transparent color sheets. No identifying information will be recorded.

You will then be asked to read passages on a computer screen while your eye movements are monitored. There are no anticipated risks with participating in this experiment. The eye-tracker that you will be using will require some adjustments in order to align your eye so that the computer can track it. The entire session should last approximately an hour.

WHAT ARE MY BENEFITS OF BEING IN THIS STUDY?

You will receive three subject pool credits for your participation in this study.

WHAT ARE my RISKS OF being in THIS STUDY?

We believe there are no known risks associated with this research study; however, a possible inconvenience may be the time it takes to complete the study.

HOW WILL MY PERSONAL INFORMATION BE PROTECTED?

The following procedures will be used to protect the confidentiality of your study records and, if applicable, of audio or videotapes. The researchers will keep all study records (including any codes to your data) in a secure location. Research records will be labeled with a code. A master key that links names and codes will be maintained in a separate and secure location. The master key and audiotapes will be destroyed six (6) years after the close of the grant or three (3) years if unfunded. All electronic files (e.g., database, spreadsheet, etc.) containing identifiable information will be password protected. Any computer hosting such files will also have password protection to prevent access by unauthorized users. Only the members of the research staff will have access to the passwords. At the conclusion of this study, the researchers may publish their findings. Information will be presented in summary format and you will not be identified in any publications or presentations.

WHAT IF I HAVE QUESTIONS?

Take as long as you like before you make a decision. We will be happy to answer any question you have about this study. If you have further questions about this project or if you have a research-related problem, you may contact the principal investigator, Rhonda Morrison at 413-546-3170.

If you have any questions concerning your rights as a research subject, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at (413) 545-3428 or humansubjects@ora.umass.edu.

CAN I STOP BEING IN THE STUDY?

You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

WHAT IF I AM INJURED?

The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subjects research, but the study personnel will assist you in getting treatment.

SUBJECT STATEMENT OF VOLUNTARY CONSENT

I have read this form and decided that I will participate in the project described above. The general purposes and particulars of the study as well as possible hazards and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time.

_________________________ _____________________ __________
Participant Signature: Print Name: Date:

By signing below I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

Signature of Person Obtaining Consent	Print Name:	Date:

APPENDIX E

CONSENT FORM – COMMUNITY PARTICIPANTS

Informed Consent Form

This experiment will take place over two sessions. At the first session, you will be screened for visual perception in reading. Based on the results of this screening, you may be asked to complete further reading tasks in the Eye Movement laboratory in Tobin Hall.

Session One - Screening: You will be given a questionnaire about your demographic information and reading history. You will then be given a reading and visual perceptual screening. The screening involves answering questions about your reading experiences, performing perceptual tasks with printed figures, and reading text through transparent color sheets. This screening session take approximately one hour. Information obtained from this session will be kept confidential. You will receive $11 for participating in this part of the study.

Session Two – Reading and Eye Movement: The second session will take place in the eye movement laboratory in Tobin Hall. Upon arrival to the lab, you will be given text to read for approximately five minutes. You will then be audio taped as you read aloud passages with and without the transparent color sheets. No identifying information will be recorded.

You will also be asked to read passages on a computer screen while your eye movements are monitored. There are no anticipated risks with participating in this experiment. In order to undergo the eye movement procedure, it is necessary that you have normal, uncorrected vision or wear soft contacts. Please tell the researcher if you are wearing contacts. The eye-tracker that you will be using will require some adjustments in order to align your eye so that the computer can track it. The entire session should last approximately an hour. You will receive $11 for participating in this part of the study.

If at any time you wish to discontinue your participation, you may do so without penalty. Your data will remain strictly confidential. If you would like a copy of the informed consent form, the experimenter will provide you with a copy. In addition, if you are interested in obtaining more information about this research, please contact Rhonda Morrison 413-546-3170. If there are any complaints/comments regarding the experiment, you can contact Keith Rayner at 545-2175. Alternatively you can contact the Human subjects review board at 545-3428 or HumanSubjects@ora.umass.edu. At the end of the experiment, we may ask you if you are interested in doing more psychology experiments in the eye-tracking lab in the future, for either money or credit. If you do indicate that you are interested, we may call you again to schedule you for another experiment.

If you would like to participate in this experiment, please read the following statement. If you agree with its content, then sign below. Thank you.

“I have read the preliminary description of this experiment and agree to participate. I understand that there are no anticipated risks, and I am free to discontinue my participation at any time without penalty.”

Name: ____ Date: __________________

Signature: ____

APPENDIX F

Tables of Questionnaire Results

Table F.1 Number of Hours Spent Reading Per Week

Hours read per week	M	SD
Read for pleasure	4.13	4.93
Read for work/school	9.58	8.05

Table F.2 Lighting Preference

Lighting Conditions	**No. of People**
Bright	15
Medium	5
Dim	5
No Preference	1

Table F.3 Corrected Vision

Vision Correction	**No. of People Reporting**
Contacts	10
Glasses (for distance)	1
No	11
Reading glasses	2

IRPS Results

Table F.4 Irlen Diagnosis Categories

Category	**No. of People**
Excellent	10
Good	7
Possible	7

Table F.5 Number of Overlays Chosen

No. of Overlays	No. of People
One	12
Two	10
Three	2

Table F.6 Overlay Color Preference

Color	No. of Times Chosen (alone or in combination)
Blue-gray	11
Goldenrod	0
Gray	5
Green	5
Peach	3
Purple	6
Rose	0
Turquoise	7
Yellow	1

Table F.7 Glare vs. Nonglare

Glare	8
Nonglare	14

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