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DISSERTATION

# SCOTOPIC SENSITIVITY/IRLEN SYNDROME AND READING IN COLLEGE LEVEL STUDENTS

Submitted by

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In partial fulfillment of the requirements

for the Degree of Doctor of Philosophy

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Spring, 1999

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COLORADO STATE UNIVERSITY

March 29, 1999

WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY CHRISTINE A. MASON ENTITLED SCOTOPIC SENSITIVITY/IRLEN SYNDROME AND READING IN COLLEGE LEVEL STUDENTS BE ACCEPTED AS FULFILLING, IN PART, REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

Adviser

Department Head



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ABSTRACT OF DISSERTATION

SCOTOPIC SENSITIVITY/IRLEN SYNDROME AND READING
IN COLLEGE LEVEL STUDENTS

This study investigated whether a recommended treatment for Scotopic Sensitivity/Irlen Syndrome (SS/IS), colored overlays, was more effective in improving reading disabled college students' reading scores than either reading skills instruction or no treatment. It was hypothesized that subjects using colored overlays would perform significantly better on posttest measures of Reading Rate and Reading Comprehension than would subjects receiving an alternative treatment or no treatment.

To test these hypotheses, 30 subjects were selected who demonstrated low reading abilities on the Nelson-Denny Reading Test and who also demonstrated symptomatology of SS/IS in the severe range as measured by the Pre-Assessment for Scotopic Sensitivity. Subjects were then divided into three treatment groups of 10 subjects each: Group I - colored overlays, Group II - reading instruction, and Group III - no treatment.

After receiving treatment, subjects were posttested on the Nelson-Denny for Reading Rate and Reading Comprehension. Pretest to posttest changes on these two dependent variables for the three treatment groups were analyzed for significance using Repeated Measures Analyses of Variance (ANOVAS). Significant Time by Group interaction effects were expected for both variables.

Contrary to expectations, the ANOVA testing for the Reading Rate variable did not indicate a significant Time by Group



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interaction. However, results of the ANOVA performed for the Reading Comprehension variable, as predicted, did show a significant Time by Group interaction. In other words, there was significant differential improvement over time in Reading Comprehension related to group membership.

An examination of group means for Reading Comprehension showed that Group I (colored overlays) improved more than Group II or Group III. Nonetheless, *post hoc* testing utilizing the Sheffé Test failed to detect significant posttest differences in pairwise comparisons of the three groups. It was hypothesized that the small number of subjects per group and the conservative parameters of the test were responsible for this failure.

Due to the statistical outcomes obtained in this study, it was suggested that similar studies in the future utilize more appropriate measures of reading rate and increase the numbers of subjects.

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## ACKNOWLEDGMENTS

The author wishes to express her appreciation to Dr. Charles Davidshofer, Chair of the Dissertation Committee, for the ideas, support, and advice he has contributed toward the successful completion of this study. Dr. Wayne Viney, Dr. Kathleen McNamara, and Dr. Jerry Bigner, committee members, have been supportive and extremely patient throughout the entire process.

Many thanks are extended to Helen Irlen and Shirley Wells of the Irlen Institute in Long Beach, California for their generous sharing of information, data, and materials. Dr. Robert Williams of the Irlen Clinic of Fort Collins has also been very helpful in sharing his knowledge regarding the clinical assessment and treatment of Scotopic Sensitivity/Irlen Syndrome. Dr. Gregory L. Robinson, a prolific researcher and clinician at the University of Newcastle, Australia, has provided access to his published and unpublished manuscripts and has been an invaluable e-mail consultant.

This study could not have been completed without the cooperation of the staff of the Learning Assistance Center at Colorado State University, the hard work of Heather Brown, undergraduate research assistant, and the contributions of the many students who served as subjects. Finally, the author extends her sincere gratitude to her husband, Dave Noble, who has graciously endured the hardships of graduate school with a smile on his face and love in his heart.



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# CHAPTER I

## Introduction

According to the United States Department of Education (1997), there are over 2.5 million students in kindergarten through twelfth grade who have been identified with learning disabilities. This figure represents approximately six percent of the total enrollment in public schools. Figures also indicate that over one third of the students who receive special education services in public schools enroll in some type of post secondary education program. Additionally, a growing number of college students are being diagnosed with learning disabilities after they enter college (Zigmund & Thornton, 1988).

At Colorado State University, where the study described in this paper was conducted, approximately 2% of the students are receiving support services to help them achieve academically after being diagnosed with learning disabilities (Office for Resources for Disabled Students, Colorado State University, 1997). The majority of these students report some difficulty with reading, although relatively few have been labeled "dyslexic."

Traditionally, students with reading problems have used tutoring, taped textbooks, outlines, notes, discussion, short but frequent study periods, and other alternative methods of learning required material (Gearheart & Gearheart, 1989). However, knowledge about and utilization of newer techniques may also be important for this population, as the quantity and level of difficulty of required college reading tends to be higher than that



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required of the general population of adults.

Because most research on reading, reading disabilities, and treatment of reading problems has focused on elementary and secondary students, college students have rarely been studied and have been somewhat neglected in these research areas. This paper is one attempt to rectify that situation.

## Definition and Prevalence of Dyslexia

In 1877, Kussamaul described the inability of some adults to read as "word blindness." Berlin introduced the term "dyslexia" in 1877. Since then, there has been increasing interest among educators and, most recently, the general population, regarding the causes and treatments of reading problems. It has been estimated that 4-5% of the population of the United States suffers from dyslexia, also known as developmental reading disability (Duane, 1991).

Cruickshank (1990) ranks dyslexia as a subcategory of learning disabilities. He further asserts that, like other learning disabilities, dyslexia is the result of perceptual processing anomalies and has neurological substrates. Dyslexia, according to Pravadis (1990), may be defined as "an unexpected severe reading retardation" which is not explained by any known physical, intellectual, or environmental factors. In other words, persons with dyslexia would be expected, according to their intelligence and education, to be reading at a much higher level of proficiency than they do.



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## Neurological Mechanisms and Reading

Most researchers working in the field of dyslexia appear to agree with a neurophysiological hypothesis as the most logical explanation of the etiology of dyslexia (Pravadis, 1990). However, the specific neurological mechanisms responsible and the most productive treatment interventions remain hotly debated topics.

Duane (1991) points out that reading consists of both decoding (i.e., sound-symbol association and sequencing) and comprehension, a more complex skill that combines neurological, experiential, and environmental components. He also believes that reading skills are primarily based on auditory processing abilities and facility with oral language. Although Snowling (1991) emphasizes the importance of auditory-language skills, she also highlights the importance of accurately assessing visual cues and developing an "automatic" sight vocabulary, thus adding visual perception and processing to the list of abilities necessary for both beginning and advanced readers.

Christenson, Griffin, and Wesson (1990) present an overview of various theories of causation regarding reading disabilities. They posit that neurologically based disruptions of three major reading processes, singly or in combination, are responsible for specific forms of dyslexia: 1) eidetic (sight vocabulary or whole word) processing centered in the angular gyrus region of the brain; 2) phonetic (word analysis by sound) processing located in Wernicke's area; and 3) nemkinesia (memory for motor movement) processing, which occurs in the motor cortex.



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Interestingly, these authors, all optometrists, recognize the importance of visual skills efficiency and of visual-perceptual-motor abilities in the reception and processing of visual material (i.e., the printed word); but they agree with most other current researchers of dyslexia in saying deficits in visual processing are not causal. The authors contend that such deficits, if present, only contribute to an already existing condition. They suggest that relieving or remediating visual discomfort or perceptual processing problems (usually by vision therapy), can contribute to the overall progress of a poor reader, but cannot "cure" dyslexia. One question that remains unanswered by Christenson et al., however, is how visual perception is related to the functioning of the aforementioned specific reading processes and what it means to the development of those processes if the more basic function of visual perception is consistently inaccurate.

Lovett (1986) and Rourke (1989) both identify sub-groups of students who have reading problems based on visual based perceptual deficits. Lovett posits that these deficits could lead to problems in word recognition, fluency, and accuracy. He also cites several studies which have found that children with reading disabilities process visual information at a significantly slower rate than nondisabled children.

Sakitt (1976) and Riding and Pugh (1976) suggest that certain visual distortions present for some readers may be caused by overlapping visual images or "extended iconic persistence," in which the sensory image is maintained on the retina for longer than



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the stimulus exposure time. Stanley and Hall (1973) also suggest that sensory register images that persist longer than the normal span of time and interfere with subsequent incoming stimuli may be present in children with reading disabilities.

Lovegrove, Martin, and Slaghuis (1986) posit a deficit in the transient visual subsystem, which inhibits the overlapping of visual images between fixations. This is thought to be connected to eye movement, as the eye focuses from one point to the next on a line of print. These authors suggest three measures of transient visual processing: 1) temporal processing across spatial frequencies, 2) contrast sensitivity, and 3) sensitivity to flicker. They argue that a large number of readers with disabilities show performance deficits in these measures of the transient subsystem.

Lovegrove (1991) has further researched the impact of vision and visual perceptual anomalies on reading. He remains convinced that, although poor phonological and lexical processes may prevail as causal factors in reading disability, impaired visual perception is an important causation factor in at least some cases of dyslexia. Thus, Lovegrove posits a direct connection between the receptive visual pathway, visual perception, visual association, and reading ability/disability, a hypothesis that has been widely disregarded in the literature.

Pravadis (1986), after years of collecting data on eye movements and visual processing of subjects with dyslexia versus those who read normally, concludes that saccadic eye movements



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(rhythm, smoothness, accuracy, span, and focus) are significantly less regular and efficient in the former group. His data suggest that subjects with reading disabilities have more erratic eye movements, irregular fixations, regressions, and shorter spans of word focus than more accomplished readers.

Williams, LeCluyse and Rock-Faucheux (1992) suggest that not only is the transient system inefficient in poor readers, but the sustained system (activated at fixation and functioning to extract clear visual detail from letters and words) may persist as the eye transitions and then fixates at a new location, thus causing image overlapping. In support of this hypothesis, Williams, Brannan, and Lartique (1987) found that when visual search task arrays were blurred, good readers' performance decreased slightly, while poor readers improved their performance dramatically.

A related conceptual framework for viewing visual phenomena includes the functions of the magnocellular and parvocellular subsystems of primate vision (Breitmeyer, 1989; Livingstone & Hubel, 1987). According to this view, fast, low-contrast information (transient, saccades) is handled by the former subsystem; while slow, high contrast information (sustained, fixations) is handled by the latter. Livingstone, Rosen, Drislane, and Galaburda (1991) added credence to the magnocellular-parvocellular theory of causality for visual perceptual problems by examining the brains of persons who had dyslexia. They found that the magnocellular layers in the lateral geniculate body of the thalamus were more disorganized and had smaller cells in the brains



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of those with dyslexia than were apparent in the brains of normal controls. Furthermore, the brains of both groups did not differ in parvocellular configuration. Thus, a stronger parvocellular ability was predicted for some persons suffering from dyslexia, with weaker (and thus disruptive) magnocellular function.

Lovegrove, Garzia, and Nicholson (1990) further suggest that an abnormal magnocellular subsystem may defectively inhibit the parvocellular system after each fixation, thus allowing afterimages to persist in some readers. These authors found that 75% of the subjects with specific reading disabilities in their study showed deficits in transient system functioning.

Evidence supporting this explanation has been provided in studies which have shown subjects with reading disabilities have difficulty detecting visual flicker (Solman, Cho, & Dain, 1992) and have slower visual evoked potentials for rapid, low-contrast visual stimuli while showing normal responses to slow, high-contrast stimuli (Livingstone, Rosen, Drislane, & Galaburda, 1991).

However, Johannes, Kussmaul, Munte, and Mangun (1996) attempted to replicate Livingstone's research with persons with dyslexia by measuring both transient and steady state visual evoked potentials using several pattern reversal rates and contrast levels. No differences between the dyslexic and control groups were discovered at any level of stimulus presentation. It is possible that with the small numbers of subjects tested by these perceptual studies, experimental groups may have been inadvertently weighted with either visually based dyslexia or auditorily based



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dyslexia, thus accounting for the difference in outcomes.

Also in contrast to the studies cited above, Hulme's (1988) review of the literature found very little evidence to support the hypothesis that visual processing deficits are causal to dyslexia. Hulme also pointed out that, even though poor visual processing and reading disability are correlated in some cases, it does not prove that the former causes the latter. Stronger evidence for such a causal connection, according to Hulme, would be provided by researching the efficacy of intervention strategies derived from the knowledge of such deficits. In other words, if a specific intervention for dyslexia is based on a specific theoretical construct regarding visual perception and processing anomalies, and if that intervention helps alleviate the symptoms of dyslexia, then the supposition that visual processing is a causal factor is supported by direct evidence.

Rourke (1990) perhaps has the broadest view regarding causality, suggesting that the population of persons with reading disabilities is quite heterogeneous for causal factors, abilities, skills and optimal treatment interventions. He indicates that dyslexia may have multiple etiologies including, but not limited to, central nervous system, auditory processing, and visual processing factors. Because of this heterogeneity, it can be expected that test results will also vary, depending on the sample of dyslexics being studied.



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Theory and Practice

Difficulty with the definition and etiology of dyslexia may be inherent in the complexity of the disorder. It may also relate to the fact that many conclusions about dyslexia have been reached operationally, that is by designing theoretical constructs regarding brain function from behavioral observations and self-report and not from direct observation of the brain itself as the reading process occurs.

The theoretical constructs which explain etiology often guide the selection of treatment modalities. Griffin and Walton (1985) have provided an extensive overview of treatment possibilities for specific types of dyslexia. They include suggestions for treating eidetic, phonetic, nemkinetic, and combination forms of reading disability, emphasizing using cognitive/neurological strengths in compensatory ways first, while later attempting to slowly remediate weaknesses. Because these authors see visual and visual perceptual functioning as problems peripheral to dyslexia, they suggest ocular-motor training and exercises only as adjunct therapy in specific cases.

Many educators and psychologists working with students who exhibit learning and reading disabilities discover their own theoretical constructs in a manner less rigorous and somewhat reversed from the traditional experimental method. The *modus operandi* in these cases seems to be summed up by "pay attention to whatever works."



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Helen Irlen and "Scotopic Sensitivity/Irlen Syndrome"

Helen Irlen, a researcher and educator at the University of California - Irvine, after working with college students with learning disabilities for several years, used such a method. In her pursuit of treatments to improve reading ability in students with reading problems, she first discovered what worked for many of these students, then tried to hypothesize why.

In 1983 Helen Irlen presented a paper to the American Psychological Association. In it, she introduced her hypothesis that a specific visual perceptual problem (later named Scotopic Sensitivity/Irlen Syndrome or SS/IS) was at least partially responsible for the academic difficulties of a significant number of students with learning disabilities. She described the problem as a deficiency of the brain's visual cortex in processing full spectrum light.

Irlen hypothesized that certain people are overly sensitive to specific wavelengths of light, resulting in perceived distortions of the visual field. Such distortions, according to Irlen, could interfere with the processing of visually presented material, including letters, numbers, and musical notations. Reading rate, efficiency, comprehension, attention, and time on task could be affected. Furthermore, eye strain, headaches, and fatigue might be concomitant symptoms. Irlen had reached these conclusions by interviewing over 1,000 students with reading problems at California State University between 1981 and 1983. From that group she had discovered a subgroup which appeared to exhibit certain



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difficulties with visual perception.

After trying various treatments with 37 of these selected subjects, Irlen noticed one of her students using a transparent red plastic sheet on top of her reading page. Intrigued by the possibilities, Irlen proceeded to experiment with various colors of plastic overlays in helping her subjects. Eventually she also produced colored lenses (or filters) that could fit in eyeglass frames.

The results in reading improvement for some students when using overlays and filters were remarkable (Irlen, 1991). Not only had she hypothesized a cause for certain learning difficulties, but Irlen now believed she had found an effective treatment as well. From the data Irlen has collected over several years, she has estimated that about 45-65% of persons with reading problems and about 15% of readers who don't report reading problems experience symptoms of SS/IS (Irlen, personal communication, 1997).

It should be noted here that Irlen's (1983, 1989, 1991) descriptions of the possible mechanisms contributing to SS/IS did not mention the transient visual system or the magnocellular pathway. She posited abnormal retinal and neurological responses to full spectrum light as the probable cause. It remains to be seen whether all of these factors interact in some way to produce the full spectrum of scotopic symptoms.

Symptoms of SS/IS

According to Irlen (1989) individuals with SS/IS have



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difficulties in one or more of the following areas:

1) Light Sensitivity: A sensitivity to glare, brightness, and intensity of various lighting conditions, especially fluorescent lighting. Reactions may include discomfort and difficulty concentrating while reading and working under fluorescent lights and driving at night.

2) Inadequate Background Accommodation: The inability to accommodate to black/white contrast in contexts including textbooks, math pages, and sheet music. Reports include the inability to tolerate the background of a page, which may appear to glare or dominate, making characters less readable.

3) Difficulty With Print Resolution: The inability to read the print easily and free from distortions, whether involving words, numerals, or musical notes. Problems include, but are not limited to, print that shifts, moves, or disappears.

4) Restricted Span of Recognition: The inability to read groups of letters, notes, numerals, or words at the same time. Difficulties include an inability to track, identify words, skim, or speed read.

5) Difficulty With Sustained Attention: A limited ability to concentrate while reading, writing, or working on a computer. Problems reported include requiring frequent breaks, becoming drowsy and/or restless, or needing to employ strategies to stay on task.

6) Poor Depth Perception/Gross Motor Activities: The inability to judge distance and spatial relationships accurately. Reported problems include difficulty with escalators and/or walking up and down stairs, bumping into things, poor driving judgment, poor ball handling in sports, and difficulty judging differences in height and depth.

Treatment for SS/IS

There are two related treatments that Irlen developed for correcting SS/IS: 1) the use of one of more colored transparencies (overlays) to be placed directly over the reading page; or 2) the use of colored plastic lenses (filters) fitted into eyeglass



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frames. There are nine colors of overlays available (used singly or in combination) and 55 filter colors (which can be combined into thousands of tint and saturation selections). The diagnostic process for the former may take one or two hours and is considered a screening process, while the process for the latter may take several hours. Often, if persons benefit from overlays, they decide to continue with the more in depth (and expensive) filter selection process.

Both methods putatively effect how the retina and the brain process specific spectral bands of light, by modifying the wavelengths (frequency bands) of light that are processed inefficiently by an individual's visual and perceptual systems. Apparently, for individuals with SS/IS, color lessens the distorting effects of light's intensity and glare, as well as those produced by the black/white contrast of print on paper. Once these effects are eliminated or lessened, Irlen has contended, reading becomes more efficient, less effortful, and less likely to illicit the SS/IS symptoms listed above.

International Interest

By 1985, an Australian journalist had convinced Irlen to appear on the television show 60 Minutes Australia. Her segment of the show, "Rose Coloured Glasses," drew the attention of Dr. Paul Whiting from Sydney University. After visiting Irlen in the United States, Dr. Whiting returned to Sydney University and opened the world's first SS/IS clinic. To date, most of the research on SS/IS



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has been conducted in Australia, closely followed by England and New Zealand. Irlen founded The Irlen Institute in Long Beach, California to promote assessment, treatment, and research of SS/IS in the United States and worldwide.

In 1988, Irlen appeared on 60 Minutes (this time in the United States) in a segment titled "Reading by the Colors." Public interest was stirred, and requests for information poured into the Irlen Institute. Research interest in SS/IS, which had been mainly limited to foreign and California institutions, spread to other areas of the United States.

In 1991, Irlen published a book, Reading by the Colors, detailing the inception, development, and ongoing applications of her definition, diagnostic procedures, and treatment procedures for SS/IS.

As of September, 1998, there were 83 official Irlen Clinics in various parts of the world, with 46 in the United States (Irlen Institute, 1998). In addition, there were several thousand certified SS/IS screeners (who may or may not be affiliated with clinics). Current procedures for diagnosis and treatment include: 1) interview, history, medical and vision exam review; 2) Pre-Assessment for Scotopic Sensitivity (PASS, Irlen, 1990); 3) Irlen Reading Perceptual Scale (IRPS, Irlen, 1988); 4) overlay selection; 5) Irlen Differential Perceptual Scale (IDPS, Irlen, 1986); 6) colored filter selection; and 7) follow-up.



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Related Research

The distortions described by Irlen (1983) were similar to those reported by Meares (1980), Whiting (1985), and Stein and Fowler (1985). Earlier research by Bourna and Legein (1977) and McIntyre, Murray, Cronin, and Blackwell (1978) had identified a restricted visual span of recognition in poor readers similar to that posited by Irlen.

Conventional eye examinations test acuity, refraction, eye coordination, focus, and look for structural anomalies and diseases of the eye (Rickelman & Henk, 1990). They do not deal with such perceptual issues as photophobia (sensitivity to light intensity and glare), background accommodation (adjustment to black/white contrast on a printed page), visual resolution (seeing without distortions), span of focus (perceiving groups of symbols simultaneously), or sustained focus (performing precise visual tasks for long periods of time). Problems with the aforementioned visual perceptual processes can clearly affect one's ability to read and perform other visual tasks without ever being detected in a routine exam. These are the very processes which are assessed and treated in the procedures designed by Helen Irlen for Scotopic Sensitivity/Irlen Syndrome.

The term "scotopic" refers to the ability of the eye to adjust to seeing in low levels of light and is related to the functioning of the rods. According to an extensive literature review by Evans and Drasdo (1991) the loss of scotopic sensitivity which produces the condition of "night blindness" has been well documented, but



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the authors found no evidence to suggest that an opposite type of disorder exists due to excessive scotopic sensitivity. However, there was also no evidence submitted by these authors to prove that such a condition cannot or does not exist.

It has been documented that a subset of epileptic patients develop a convulsive response to certain types of visual stimulation, especially patterns of lines (Newmark & Perry, 1979). Wilkins and Nimmo-Smith (1987) have suggested that persons with epilepsy and others, such as persons suffering from migraines, may have localized patches of cells in the visual cortex that are "hyperexcitable" and receptive to specific wavelengths of light. They posit that the use of color may reduce the effects of these specific wavelengths in vulnerable individuals, thus reducing pattern sensitivity.

According to Rickelman and Henk (1990), sensitivity of some persons to specific wavelengths and frequencies of the white light spectrum can overstimulate the retina, causing neurons to send inappropriate signals to the brain. In trying to accommodate for these distortions, the eyes and brain may tire more rapidly than would be so for a person without this condition. These authors speculate that overlays and filters may selectively reduce the input of these specific wavelengths, thus eliminating their impact before they reach the retina or the brain and allowing more efficient completion of visual tasks.

Wilkins and Nimmo-Smith (1984, 1987) have explored the relationship between patterns of black and white contrast and



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visual discomfort, headaches, and anomalous visual effects (illusion of color, shape, and motion). They call these effects "pattern glare," and hypothesize that printed text may elicit pattern glare in susceptible readers. The authors suggest that reducing pattern contrast may be one way of lessening such visual effects.

Solman, Dain, and Keech (1991) tested children classified as good and poor readers under four lens conditions (best color, worst color, grey, and clear). They measured contrast sensitivity thresholds over varying spatial frequency ranges. The authors found that the best colored filter selected for the disabled readers dramatically reduced sensitivity as the spatial frequency moved into the range of printed material. In contrast, there was little change in sensitivity for good readers using their best filters. The authors concluded that colored filters might improve "transient-on-sustained" inhibition for poor readers.

Wilkins, Nimmo-Smith, and Jansons (1992) in testing nine children who reported visual perceptual distortions and were experiencing severe reading difficulties, found that when subjects read through an aperture in a box lighted by a self-adjusted "colorimeter," specific adjustments of colored light produced abatement of symptoms of distortion. Furthermore, eight of these children reported the same relief when fitted with trial lenses dyed with tints analogous to their preferred setting of colored light.

Follow-up studies (10-12 months) performed by MacLachlan, Yale



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and Wilkins (1993) on 55 patients who had been prescribed precision tinted colored lenses (not Irlen's) for symptoms such as eye strain, perceptual distortions, and reading problems found that 45 of the patients were still using their lenses. (Seventeen had also needed refractive correction, which had been provided.) Of these 45, 44 reported improvements in reading and reduction in headaches and/or eye strain.

SS/IS Research

Research which deals specifically with SS/IS and its treatment has produced mixed results and received much criticism, especially from optometrists and opthamologists. Scientists have criticized studies for various methodological reasons, the most frequently mentioned one being the lack of suitable controls (Evans & Drasdo, 1991; & Stanley, 1990).

Robinson (1990) has attributed the mixed results of SS/IS studies to the generally accepted notion that reading disabilities are heterogeneous disorders, and has suggested that print clarity is only one factor among many influencing reading achievement. Therefore, according to Robinson, other factors may dilute the positive effects that SS/IS treatments may have upon reading.

Interestingly, most of the SS/IS studies (whether outcomes have been positive, negative, or mixed) have been conducted in Australia, New Zealand, and England with school-age children. Very few studies have been completed in the United States, and even fewer with adult subjects.



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One of the few such studies was Irlen's initial study (1983) which investigated 37 college students with learning disabilities, ages 18-49 and 70 other clients, ages 9-54. Improvements reported included clarity and stability of print, reading rate, focus, reduction of eye strain, and improved comprehension. However, in this earliest study, there was no standardized test of improvement, no statistical analysis, no control group and no control for improvement due to "heightened expectations" (Robinson, 1994).

Miller (1984) also provided interesting descriptive data on Hawaiian community college students. He screened high and low reading ability students and determined that 74% of the low ability readers were scotopic (according to Irlen's original criteria). Only 15% of those with high reading ability showed scotopic symptoms.

Robinson and Miles (1987) studied 42 subjects (ages 9-74) with reading problems under three conditions: 1) random colored plastic overlay, 2) clear plastic overlay, and 3) colored plastic overlay self-selected by subject as reducing visual symptoms. For subjects high on SS/IS measures, the third condition produced significantly higher mean scores for word matching, letter recognition, and number recognition(but not word recognition).

Both adults and high school students who were enrolled in a special education program and performed poorly on SS/IS measures (Irlen, 1983) were studied by Adler and Atwood (1987). The experimental group received preferred tinted lenses; the control group did not. Retesting showed the former group lessened visual



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inefficiency (errors), eye strain, and reading effort, and improved length of sustained focus, while the latter did not. The experimental subjects also reported less sensitivity to glare, better visual resolution, and greater span of focus. However, as Evans and Drasdo (1991) pointed out, the experimental group received other treatment as well, while the control group received no treatment of any kind.

Wilkins and Neary (1990) examined 20 children and teenagers who had used Irlen lenses for several months on a variety of visual tasks. Comparisons were made using Irlen lenses, neutral density lenses, and refractive correction lenses. Subjects reported less discomfort and experienced fewer perceptual anomalies when wearing the Irlen lenses.

Questionnaires were sent to tinted lens wearers and/or their parents in several studies (see Burgess, 1990; Fricker, 1989; MacLachlan, Yale, & Wilkins, 1993; and Whiting 1985, 1988). Results indicated a high rate of user satisfaction and symptom reduction among subjects who responded to the questionnaire. However, these may have been favorably biased samples, with no apparent control for the placebo effect.

## Reading Performance Studies

Warnock, et al. (1988) found little or no improvement on the Neale Analysis of Reading Ability in children with reading disabilities who were fitted with tinted lenses. Similarly Gole et al. (1989) found that children with dyslexia, when fitted with



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their choice of red, green, yellow, or blue lenses, made no more improvement on the Neale than dyslexic children in a control group matched by age and sex. However, it should be noted that the children in these studies were not assessed for scotopic symptoms, nor were the treatment colors used those developed by Irlen.

On the other hand, Kyd, Sutherland, and McGettrick (1992) observed immediate improvement in reading rate for 93% and reading comfort for 100% of subjects with scotopic symptoms (although comprehension did not improve) when these children were allowed to use preferred colored overlays. Control subjects, who were nonscotopic, actually showed a decline in both rate and comprehension when retested with overlays. Chan and Robinson (1989) compared an experimental group of children with reading disabilities who used tinted lenses to a control group with reading disabilities who did not. They found that the former group needed less instruction and performed significantly better on a reading task than the latter.

Gregg (1989) also compared groups of children with dyslexia. The experimental group consisted of those who expressed a strong to medium color filter preference, while the control group expressed a weak preference. Both groups were pretested without colored filters and post-tested with them. Of the experimental group, 80% improved their reading scores, contrasted to 0% of the control group.

Kruetter and Strum (1990) found significant improvement in reading comprehension, rate, accuracy, and word identification in



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a group of students with reading disabilities after four months of using Irlen lenses as compared to a control group of average readers. Robinson and Conway (1990) not only found significant improvement in reading comprehension and reading accuracy on the Neale for 44 children with disabilities using Irlen lenses over 12 months, but also found significant improvement in attitude toward school and perception of academic ability.

O'Conner, et al. (1990) compared 67 children identified as scotopically sensitive on the IDPS to 25 children identified nonscotopic. Poor test scores for scotopic subjects using preferred colored overlays rose dramatically (6 months average gain in reading rate, 19 months in comprehension) for the group using preferred colored overlays, far surpassing both nonscotopic and scotopic control groups.

In a pretest/posttest study of 295 students with specific learning disabilities, Sawyer, Taylor and Willocks (1994) discovered that the experimental group (children who had been allowed to use one of four colored overlays) performed significantly better on posttest reading measures than did the control group (no overlays). However, teachers' ratings of the children's confidence, interest, and amount of reading did not improve.

Robinson and Foreman (in press) performed a placebo controlled study for reading achievement with an experimental sample of 88 children showing moderate to high symptoms of SS/IS and having reading and/or other academic problems. They also included 35



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children with reading problems but no scotopic symptoms as a control group. Testing of reading skills was completed four different times across a time frame of 18 months. The control group used no filters; whereas one experimental "diagnosed" group used their optimal diagnosed colors throughout the study. Two other groups, which used placebo (varied) colored filters or blue filters, were switched to their optimal diagnosed tints midway.

Statistically significant total improvement was shown for all groups in reading accuracy and for all groups in reading comprehension. However, for comprehension the original diagnosed lens group and the placebo lens group (which switched to optimal tinting midway) achieved the greatest gains, both at $p < .0001$. The blue lens group (which also switched) came next at $p < .001$. Finally the control group also showed significant gains at $p = .005$. None of the groups showed significant improvement in reading rate. Robinson and Foreman also noted a significant increase over time on a Perception of Ability Scale for the "diagnosed group." However, none of the other groups achieved significance on this measure.

Studies Concerning Visual/Perceptual Performance

Robinson and Miles (1987) tested subjects aged 9-74 years who had inquired about Irlen lenses on four timed visual search tasks with clear, random, and optimally selected colored overlays. There were statistically significant differences in performance favoring the third condition. However, there were no differences among



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group means when groups scoring either low, medium, or high on the Irlen Differential Perceptual Scale were compared. In other words, all groups appeared to have benefitted equally, no matter what the level of their scotopic symptoms. Perhaps one explanation for this finding is that no pretest to posttest improvement for these groups was measured on the visual search tasks. The posttest measured means may have been equal; but the low, medium, and high groups may have started out at significantly different levels of performance prior to color correction.

Similarly, Wilkins and Neary (1991) found that 20 Irlen lens wearers, ages 8-18, performed significantly better on a visual search task using their Irlen filters than they did either with neutral density filters or lenses with refractive correction only. They posited a specific subgroup of poor readers who experience "anomalous visual effects" (illusions) while viewing high-contrast patterns and suggested a possible benefit of tinted lenses may be to reduce "pattern glare" and/or possibly to reduce the temporal effects of fluorescent lighting on patterns of print.

In contrast to the previous two studies, Winter (1987) and Saint-John and White (1988) found no significant differences between or among poor and normal readers on visual search tasks under several lens and no lens conditions. Additionally Cotton and Evans (1990), Gole et al. (1989), and Martin, MacKenzie, Lovegrove, and McNichol (1993) found no improvement in reading or other visual tasks from using Irlen filters. One possible reason for negative outcomes in these studies is that the experimenters did not



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identify poor readers with visual perceptual or scotopic symptoms but utilized heterogeneous groups of poor readers.

Blaskey et al. (1990), randomly divided subjects (ages 9 to 51 years old) who tested positive for scotopic sensitivity into an Irlen filter treatment group, a vision therapy treatment group, or a control group. Results revealed that subjects in the first two groups reported being more comfortable with visual tasks after treatment, but none of the groups showed significant improvement in reading skills. It is important to note that 95% of the subjects who volunteered for this study had vision problems that were found by standard optometric testing, and only those subjects who showed both scotopic and standard visual symptoms were included in the final subject pool.

Evans and Drasdo (1991), in their extensive and critical review of the literature regarding SS/IS research, cited 18 major published papers between 1983 and 1991. Of those, 11 papers concluded there were clear benefits for readers with dyslexia in using colored filters or lenses. However, the authors of this review found serious research flaws in all 11 studies, complaining that lack of control groups, poor matching, small numbers, subjective data collection, and no controls for the placebo effect cast serious doubt on the scientific validity of the reported benefits. They then attacked the theory, nomenclature, symptomology, overlay and filter tints, lighting conditions, and lack of published evidence (although these same authors reviewed over 20 papers and articles on the subject) of Helen Irlen and



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others who have embraced her method of studying and treating reading disabilities.

In rebuttal to these types of criticism, Robinson's (1996) review of the literature cited 15 published studies of colored overlays, 12 of which found positive effects for reading and/or visual perceptual tasks. Two of these studies reported mixed results; and one found no positive outcomes with the use of color. (Robinson noted that for this latter study subjects were not screened for scotopic symptoms, therefore may not have been responsive to color correction.) In reviewing articles dealing with colored filters (lenses), Robinson identified 24 studies, with 17 reporting improvements in various reading tasks or skills. Two of the filter studies reported mixed results, and five found no improvement. Robinson also mentioned nine follow-up studies administered to Irlen lens users, in which the overwhelming majority of respondents (82% - 93%) reported high ratings for task improvement and symptom reduction.

Recent Research Trends

An area of investigation which seems to be expanding in the field of SS/IS research is that of exploring possible biological and/or neurological substrates of visual processing which may be involved in the etiology of SS/IS symptoms. There is some evidence to suggest (supporting Irlen's 1983 light sensitivity hypothesis) that a significant number of persons with dyslexia have a different distribution of rods and cones on the retina than



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normals (Grosser & Spafford, 1989, 1990), thus reducing their efficiency in processing full spectrum light. These authors have linked differential rod and cone distribution to the tendency found by Geiger and Lettvin (1987) of such persons to use their parafoveal (peripheral) cone-initiated vision when they read rather than their foveal (central) vision, which is the predominantly rod-assisted part of the visual field utilized most by normal readers. The foveal part of the retinal field is more sensitive to bright light and less sensitive in dim light, while the reverse is true for the parafoveal portion of the field.

In a 1994 study, Carroll, Mullaney, and Eustace found statistically significant poorer dark adaption thresholds for a group of subjects diagnosed with dyslexia and scotopic sensitivity than for a group of normal readers with no known scotopic symptoms. These abnormal dark adaptation patterns occurred in the latter stages of adaptation which are rod (rather than cone) mediated. They also occurred at two extrafoveal retinal locations, as opposed to the center of the fovea. The authors suggest that an abnormal and prolonged "rod phase" of dark adaptation may reflect an abnormality in rod photoreceptors and/or associated neurons. They further propose that a visual pathway deficit for a substantial number of dyslexics begins at the photoreceptor level, involves the magnocellular pathway, and eventually affects the visual cortex.

Most of the research related to visual perceptual processing has focused on the functioning of the magnocellular visual neurological pathway (transient system). Livingstone, Rosen, Drislane, and Galaburda (1991) and Lehmkuhle, et al. (1993)



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measured diminished or delayed evoked potentials along this pathway in persons with reading disorders. The former authors also found, in examinations of the lateral geniculate body of the thalamus, that the magnocellular cell bodies were smaller and the layers more disorganized in dyslexics' brains than were those examined in histological studies of the brains of nondyslexics.

According to Stuart and Lovegrove (1992), the visual processing deficit hypothesis implies a neuronal rather than a photoreceptor abnormality. They found that readers with dyslexia had slower flicker fusion rates and longer visual persistence in transient system (magnocellular) functioning. These authors hypothesize that such problems interfere with the processing of the sustained (parvocellular) system, which comes into play during visual fixations. Use of color filtering has been claimed to improve or prevent the overlapping between the two systems (Solman, Dain, & Keech, 1991; Williams, La Cluyse, & Rock-Facheux, 1992).

Lewine, Irlen, and Orrison (1997) utilized magnetoencephalagraphy to record steady state visual evoked magnetic fields from eight subjects with SS/IS and eight control subjects. All subjects were tested with and without colored lenses. Subjects were instructed to count flashes of light presented in the context of a reversing black/white checkerboard pattern. For normal subjects without lenses, the field pattern was clear, dipolar, and reflected accurate midline calcarine activity (focus). When these subjects used colored lenses, the pattern became much more complex reflecting multiple stimuli simultaneously. With the scotopic subjects the situation was



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reversed. That is, a complex and disorganized field was seen without lenses, whereas an organized dipolar field was perceived with colored lenses.

Extending the concept of biological etiology in a logical direction, Robinson, Foreman, and Dear (1996) have initiated a line of research into possible genetic links for SS/IS. Parents of 751 girls and boys who had tested positive for SS/IS were themselves evaluated for symptoms. (Approximately 90% were evaluated on site using Irlen [1991] screening materials; the remaining 10% were interviewed by phone.) Results showed that 84% of the children had one or two biological parents who also demonstrated sufficient symptoms to be identified as having SS/IS. The authors emphasized that the above result was not due to any expectations parents may have had prior to screening. Most of the children were referred by their schools for general learning problems, and most of the parents were unaware of both the nature of the screening procedures and the extent of their own involvement until the process actually occurred.

In evaluating their family study data, Robinson et al. (1996) found no simple genetic model (autosomic recessive or dominant gene transmission) that would fit the incidence numbers obtained. Recessive transmission estimates were too low; while dominant transmission estimates were too high (not allowing for the 16% of children who had neither parent affected). The authors implied that a more complex genetic transmission model or theory may need to be developed.

Other recent empirical studies have found that, for SS/IS



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affected subjects, colored filters improve ocular accommodation and efficiency of eye movements (Fletcher & Martinez, 1994) and binocular coordination (Evans, Cook, Richards & Drasdo, 1994). Tyrell, Holland, Dennis, and Wilkins (1995) found a significant improvement in visual search tasks for such subjects using colored lenses. They also reported that, for 23 of 60 subjects, an independent optometric assessment showed a trend toward reducing the number of extended fixations and regressions per line of print.

Adult Studies

Another area of research just beginning to open up is that of studies focusing solely on adult subjects. There are three such known studies to date (Bulmer, 1994; Irlen & Robinson, 1996; Robinson & Conway, 1996). Bulmer (1994) surveyed colored filter users (ages 18-62), 75% of whom also had reading problems. He found most respondents reported improvements in reading comprehension and accuracy, as well as clarification of visual perception and improvement in concentration while reading. Other improvements noted after beginning lens usage were in the areas of eye strain, fatigue, and incidence of headaches.

Robinson and Conway (1996) investigated the areas of reading rate, comprehension and accuracy for 38 adult subjects who were diagnosed as having symptoms of SS/IS. Testing for an experimental optimal lens group, a delayed optimal lens group and a control group was administered three times (pretest, three months, and six months). The optimal lens group showed significant improvements in all three areas of reading for comparisons at three and six months,



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(except for the area of reading rate, which showed no gains between three and six months). Similarly, the delayed lens group made gains in all three areas; but significance was not achieved for rate or accuracy between three and six months. Both experimental groups, however, achieved significant gains at all posttesting phases in comprehension when compared to their pretest scores. The control group, in contrast, showed no significant gains in any area of reading during any time frame.

These authors also tested the same subjects on the Coopersmith Self-Esteem Inventory. The results of this testing were inconclusive, showing significant gains over time for all three groups (although the optimal group achieved a higher level of significance). It is therefore possible that the placebo effect influenced self-esteem measures for all participants.

Addressing the topic of adult literacy and workplace performance, Irlen and Robinson (1996) completed phone surveys with 66 employed adults who used their Irlen filters while working. Respondents indicated moderate or considerable improvement in the following four job-related categories: productivity (94%); absenteeism (91%); reading/computers (95%); and job satisfaction (79%). Specific questions in the reading/computer category that elicited the highest percentage of positive endorsements for improvement were in the areas of reduced effort (94%), time on task (85%), glare problems (84%), and skipping words (83%).

The authors of this study concluded that a certain subgroup of adults suffer from literacy, visual accuracy, and self esteem problems on the job related to SS/IS. They also implied that



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screening and treatment for SS/IS needs to be studied, along with other work performance improvement methods, as one possible avenue of increasing productivity, reducing absenteeism and reducing dissatisfaction in the workforce.

## Rationale for the Current Study

Most of the literature on dyslexia focuses on the "bottom up" processes of decoding and encoding (see Bodor [1973], Johnson & Myklebust [1967]). However, using the broadest possible definition of dyslexia (i.e., inability to read at one's expected level of mastery) a complete understanding of the disorder cannot occur without considering comprehension, or the "top down" processes of reading, (i.e., contextual analysis, semantics, and syntax; Christenson, Griffin & Wesson, 1990). Indeed, in working with college level students, it is often the "top down" skills contributing to comprehension that are deficient, while the ability to read specific unrelated words may appear unimpaired.

Blaxall and Willows (1984) have found that the types of reading errors made by dyslexic populations tend to change from phonetic to visual as the complexity of the reading material increases. Therefore, the portion of the adult dyslexic population that is enrolled in post secondary education may have more problems with both comprehension and visual processing than with either phonetic analysis or sight word vocabulary. In essence, the college population may have moved beyond the problems of recognizing or decoding single words - at least well enough to have successfully graduated from high school and entered college.



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However, the complexity and volume of required college level reading material may exacerbate or highlight a previously unrecognized form of dyslexia in certain individuals, which may include the inability to efficiently visually process large amounts of printed material and/or the inability to sufficiently comprehend such material.

Because of the relative recency of SS/IS as a theoretical construct partially explaining reading problems, because of the scientific controversy surrounding the construct, and because of the practical benefits reported by many previous subjects and clients, the design of the current study addresses one treatment related to SS/IS (colored overlays) rather than the construct itself. The aspects of SS/IS studied, therefore, are applied rather than theoretical or explanatory. Implied in this paradigm, however, is the suggestion that if the treatment works well enough to produce statistically significant results, there is probably a related perceptual dysfunction which might be labeled SS/IS. The etiology and neurological mechanisms underlying that condition, however, still remain matters of ongoing speculation.

If, according to Hulme's (1988) suggestion, an intervention has been designed that successfully addresses some of the visual processing and comprehension components of college students' reading problems, a better idea of how dyslexia manifests and can be treated in older, higher functioning, more highly educated students might be formulated. Thus, if Helen Irlen's ideas concerning the assessment and treatment of reading problems (which have mainly been researched with younger students) are rigorously



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studied in the college population, perhaps some helpful clues to ameliorating reading difficulties for older students can be gleaned.

Research Hypotheses

In a 1996 unpublished pilot study by the author, it was determined that 75% of the student sample who referred themselves for reading problems to the Learning Assistance Center (LAC) at Colorado State University tested in the high or severe range (30 or more) on the Pre-Assessment for Scotopic Sensitivity (PASS, Irlen, 1990). Most of these students were able to improve their reading scores by using colored overlays to retake reading tests. By comparison, only 13% of a group of students not self-selected for reading problems had scotopic symptoms in the severe range as tested on the PASS. Furthermore, although no statistical tests of significance were run, reading scores did not appear to improve for these students when they took a reading test for the second time using colored overlays. Because of the surprisingly large percentage of self-referred students with reading problems who showed severe scotopic symptoms, it was decided to focus on that particular group for further research into the incidence and treatment of SS/IS in the college population.

The premise upon which the current study rests is that a significant number of college students with reading disabilities suffer from poor visual perceptual processing which negatively impacts reading rate and reading comprehension. Therefore, it is hypothesized that improving visual perceptual processing will



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improve these reading skills. The techniques being investigated in the assessment and treatment of visual processing problems are those developed by Helen Irlen. The expected outcome is that college students who show evidence of both scotopic sensitivity and reading problems will demonstrate significantly more improvement in their reading scores by using Irlen colored overlays than will comparable groups of students who either receive traditional instruction in reading or are in a no treatment control group.

Specific hypotheses tested are as follows:

I. Students with reading problems and symptoms of Scotopic Sensitivity/Irlen Syndrome who are treated with colored overlays will improve significantly more on pretest/posttest comparisons of Reading Rate than will comparable groups treated with standard reading instruction or no treatment.

II. Students with reading problems and symptoms of Scotopic Sensitivity/Irlen Syndrome who are treated with colored overlays will improve significantly more on pretest/posttest comparisons of Reading Comprehension than will comparable groups treated with standard reading instruction or no treatment.



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# CHAPTER II

## Method

### Subjects

A total of 30 university students with reading problems who had self-referred to the Learning Assistance Center (LAC, Learning Disabilities Program) at Colorado State University served as subjects for this study. All students except two (ages 40 and 48) were in the 18-28 year age range typical for college students. All were Caucasian and spoke English as their native language. There were 17 men and 13 women in the study.

Preliminary intelligence testing using the Multidimensional Aptitude Battery and/or the Wechsler Adult Intelligence Scale-III placed all subjects within the average range for IQ (standard scores 85-115, $\underline{M}$ = 102.8, $\underline{s.d.}$ = 8.7). All students selected for the study were two or more grade levels below their college placement level in reading comprehension and had been screened to determine sufficient symptomatology for Scotopic Sensitivity/Irlen Syndrome.

### Instruments

The Nelson-Denny Reading Test. Used as both a pretest and posttest for all subjects, the Nelson-Denny Reading Test (NDRT), Form G, (Brown, Fishco, & Hanna, 1993) was developed for high school and college students. Current forms of the test, including Form G, were standardized in 1991 and 1992 with three general sample populations: high school, two year college, and four year



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college. College samples were further stratified by geographic area, size of enrollment, and type of institution (public or private). In order to ensure an accurate representation of college students nationwide, a matrix of 24 cells was constructed with demographically representative numbers in each cell. Sampling within cells, once constructed, was conducted by random selection. Therefore, the four year college norms for the test provide a valid comparison group for the subjects in the current study.

The NDRT consists of two parts, Vocabulary and Comprehension. Scores are also derived for Reading Rate and Total Test. The Vocabulary section has 80 items and a time limit of 15 minutes. The Comprehension section consists of seven reading passages taken from humanities, social sciences, and science texts. There are 38 comprehension questions to be answered within a time limit of 20 minutes. There are five answer choices per question. Reading Rate is determined by timing a one-minute reading sample and marking the numerical equivalent of words read.

Nelson-Denny scores are recorded as percentiles, scaled scores, and grade equivalents and are derived by comparing subjects to norm groups at the same educational level (i.e., grades 13, 14, etc.). For the statistical purposes of the current study, scaled scores were utilized.

The Nelson-Denny is one of the few instruments written to test college population silent reading skills (Yesseldyke, 1985). Gudan (1983) reported in a literature review that the (earlier forms of) the NDRT appeared to be viable instruments for both screening students and predicting academic success. More recently the NDRT



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has been considered a very good screening assessment measure of potential reading difficulties for secondary and college level students (Pierangelo & Giuliani, 1998).

One of the early criticisms of the test (Tierney, 1985) was that no correlational studies were done to assess relationships among Vocabulary, Comprehension, and Rate. To date, no published data exists to suggest that these three measures are related. Consequently, the two measures utilized for this study, Rate and Comprehension, have been traditionally assumed to be independent.

Content validity for the NDRT, Form G, was addressed through item selection for the Vocabulary and Comprehension sections. Items were selected from a nationwide sample of currently in use high school and college texts. Items were then analyzed for difficulty level to ensure they fairly represented the range of difficulty expected for ninth grade through college students.

Discriminant validity was also addressed by utilizing point biserial correlations to evaluate discriminant (ability level) capability. Mean biserial correlations for items scored on four year college students ranged from 0.39 to 0.49 (index range = -1.00 to +1.00), which was considered "good" by the test's authors.

Concurrent validity was checked with correlational data from three California community colleges using Nelson-Denny scores and grades in college reading courses. Correlations between Nelson-Denny total scores and specific course grades ranged from .31 for a Reading Fundamentals class to .72 for an Advanced Reading class (Brown, Fishco, & Hanna, 1993).

Validity and Reliability quotients were improved from earlier



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forms (E and F) of the NDRT, which were already statistically acceptable (Brown, Fishco, & Hanna, 1993). Test-retest reliability quotients for those earlier forms were: Vocabulary, .89 - .85; Comprehension, .75 - .82; and Rate, .62 - .82 (Yesseldyke, 1985). Correlations between Form E and Form G were as follows: Vocabulary, $\underline{r}$ = .86; Comprehension, $\underline{r}$ = .76; Total, $\underline{r}$ = .86; and Reading Rate, $\underline{r}$ = .68 (Brown, Fishco, & Hanna, 1993).

The Self-Test for Scotopic Sensitivity/Irlen Syndrome. This instrument is an informal prescreening checklist consisting of 19 questions taken from Reading by the Colors (Irlen, 1991). The questions cover problematic reading behaviors and physical symptoms associated with reading discomfort. Students answer each question with a check for "yes" or "no."

Pre-Assessment for Scotopic Sensitivity. The third instrument used with all subjects was the Pre-Assessment for Scotopic Sensitivity (PASS) screening, an instrument designed by Helen Irlen (1990). The PASS consists of three sections. (Irlen, in a 1997 personal communication, refused permission to reproduce the PASS or other copyrighted materials in the appendix of this paper.)

Section I has two sets of 17 questions each, one set addressing "Reading Difficulties" and the other "Strain and Fatigue." All questions pertain to a subject's remembered reading experiences when reading for information and reaching a point of fatigue. Examples of questions are: "Do you unintentionally skip words," and "Do you get a headache?"



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Section II includes two visual perceptual tasks. The first is to read aloud individual letters in a line of print written in a foreign language (Dutch). The letters are presented in black on a glossy white background. The second task is to count aloud the number of symbols between two boxes embedded in a larger figure consisting of identical symbols. After each of these tasks is completed, participants are asked a series of questions about their visual and perceptual experiences while doing the task.

Section III consists of being required to locate and focus on a specific letter and then on a specific line of an eye chart. The following questions are then asked: 1) "Do you have difficulty recognizing the letters," and 2) "Do the letters change?"

Throughout the PASS, spaces are provided for spontaneous comments made by subjects and observations of examiners to be recorded. Each portion of the PASS is scored separately, the first four tasks on a scale of 0-17 and the last two as "No Problem" or "Problem." Numerical scores fall under the headings "N/A" (0), "Low" (1-3), "Moderate" (4-7) and "High" (8-17).

There are no known studies dealing with the validity and reliability of the PASS that can be found in the published literature. However, face and content validity can be claimed, as Irlen designed the instrument to screen for the specific symptoms which are defined as part of the construct of SS/IS. It is therefore the best method available for doing a quick but thorough screening for these symptoms.



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The Irlen Reading Perceptual Scale. The instrument used as a guideline for providing treatment to the experimental group was the Irlen Reading Perceptual Scale (IRPS) developed by Helen Irlen (1988, revised 1995). The IRPS includes three sections, with some items that are identical to those on the PASS.

Section I includes the same questions concerning "Reading Difficulties" and "Strain and Fatigue" as are included in Section I of the PASS. Therefore, subjects were not asked these questions again in order to avoid redundancy.

Section II provides seven visual perceptual tasks, only one of which (Pumpkin) is present in Section II of the PASS. Therefore, all seven tasks were completed by experimental group subjects. These tasks are: Box A, Box B, Pumpkin, Penguin, Musical Lines, Span of Recognition, and Pointing Task. After each task participants are asked a series of 17 questions regarding their subjective perceptual experience during task performance. An example of such a question is: "Do the lines/symbols stand still or do they jiggle, dance, or move?" Scoring criteria for this section are the same as for tasks on the PASS (i.e., Low, Moderate, and High numerical ratings).

Section III outlines the process of colored overlay selection and usage. Participants are asked to observe nine overlays in succession and side by side. The overlays are placed over a white card with black foreign words printed on it. Participants are asked to select the color or combination of colors which reduces visual distortion and improve print clarity. Preferred colors are chosen in succession, with double or even triple overlays being an



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option. The efficacy of the selected overlay is then tested by using it with oral and silent reading passages, and comparing that experience to reading with no overlay. A series of questions regarding the overlay vs. no overlay reading experience are asked (i.e., "Was it better, worse, or no different?")

As with the PASS, there are no known reliability or validity studies of the IRPS in the literature. However, four studies have addressed construct validity issues for the Irlen Differential Perceptual Scale (IDPS, Irlen, 1986), from which the IRPS was later developed. On the prototype IDPS, Haag (1984) found that normally achieving students performed significantly better than reading students with reading disabilities on performance tasks ($p < .01$) and diagnostic questions ($p < .05$). Miller (1984) found that overall scores of students with high reading ability were significantly different from those of students with low reading ability ($p = < .01$). Tyrell et al. (1995) found a significant association ($p < .001$) between poor (high symptomatology) scores on the IDPS and below average reading achievement. Using an adaptation of the IDPS for group screening, Robinson, Hopkins, and Davies (1995) found 12 months difference in reading comprehension scores between high and low IDPS scorers. Additionally, face, content, and construct validity may be assumed to be better for the IRPS than for the PASS, because the number of items and types of tasks related to SS/IS (and its impact on visual perception and reading) have been greatly expanded on the IRPS.

The PASS, IDPS, IRPS, colored overlays, and colored filters, all of which have been copyrighted or patented by Helen Irlen, are



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currently the only official and legal methods for the assessment and treatment of SS/IS. Therefore, considering the early state of this field of inquiry, they were used to operationally define the variables of SS/IS in this study.

Study Skills Reading Module. This module, used as an instructional guideline for one of the control groups, was designed by personnel at the LAC. It consists of several activities with accompanying handouts. The focus of the module is to improve reading comprehension, especially as it relates to reading college texts. Topics include: Textbook Study Methods, Summary of SQ3R (survey, question, read, recite, review), Reviewing a Textbook and a Chapter, Mark Your Books, and Efficient Reading Concepts and Techniques. The materials were designed to be presented in an individualized, interactive format between a study skills specialist and a student.

## Procedure

All Groups. All subjects were students who approached the Learning Assistance Center (LAC) because they were having academic difficulties. These students had not previously been diagnosed with learning disabilities and had requested testing to determine whether such disabilities might be interfering with their academic progress.

After an initial interview with an LAC staff member, these students were assigned to a routine battery of tests including the



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Nelson-Denny Reading Test and the Self-Test for Scotopic Sensitivity/Irlen Syndrome. Other tests, such as the Multidimensional Aptitude Battery and/or the Wechsler Adult Intelligence Scale-III, were included as measures of intellectual functioning.

Students who received NDRT Reading Comprehension scores two or more grade levels below their college placement levels and who marked five or more "yes" answers on the Self-Test for SS/IS were later given the Pre-Assessment for Scotopic Sensitivity by trained personnel at the LAC. (Irlen, 1991, suggested three could function as a cut score on the Self-Test, making five a more stringent criterion.) To this point, students had followed routine procedures of the LAC and had not yet become subjects for this research project.

Students who scored 30 or more on the PASS, thus exhibiting clear and sufficient symptomatology for SS/IS (in the high or severe range according to Irlen, 1990), were asked if they were interested in being research subjects. Those who answered in the affirmative were then scheduled for a treatment session with the author of the study. Students were informed that, because of the research design, portions of their treatment might be slightly delayed. Those who did not wish to participate were referred back to the LAC. Every attempt was made to complete the full process, from the initial interview to the treatment and posttesting session, within a period of four weeks.

Subject distribution consisted of blocked random assignment to groups. Subjects were blocked on severity of reading deficit



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according to their Nelson-Denny Reading Comprehension scores as follows:

1) two or three years below grade level (9 subjects)
2) four or five years below grade level (9 subjects)
3) six or more years below grade level (12 subjects)

Subjects were then randomly distributed among the treatment groups by numerical rotation, attempting to insure that equal numbers of students from each ability block were represented in all three treatment groups. This was an effort to create homogeneity of variance across groups. It was thought that students who had more severe reading deficits might show larger treatment effects. Therefore, blocking was implemented to control for a potential source of unequal variance.

Irlen (training seminar, 1997) stated that in 53 published studies, there have been no differences found between males and females in amount of improvement with treatment for SS/IS. Therefore, subjects were not matched on the basis of gender. One study (Robinson & Conway, 1996) found that adult subjects in the age range of 48-58 improved significantly more on a measure of reading comprehension when using Irlen filters than did subjects aged 18-28. Because only 2 of 30 subjects in the current study were over the age of 28, and because those subjects were placed in different groups, no further controls for age were implemented. Finally, IQ has not been shown in the literature to have a relationship to differential treatment effects. Subjects in the study, all scoring within the average range for IQ, were neither matched for IQ nor statistically tested for IQ as a covariate.

All subjects were seen individually for treatment by the



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author of the study. At the end of their treatment sessions, all subjects were posttested on the NDRT to obtain Reading Comprehension and Reading Rate scores. (The initial NDRT test scores became the pretest data.) They were then scheduled for follow-up appointments to complete any portions of the treatments they had missed and to receive additional appropriate services.

Experimental Groups

Group I - Colored Overlay/Experimental. The subjects in this group were provided with the complete screening for SS/IS as delineated in the Scotopic Sensitivity/Irlen Syndrome IRPS Screening Manual (Irlen, 1988). Objective and subjective data were gathered for each subject; and numerical scores, comments, and observations were recorded. The treatment consisted of participating in and discussing this process with the experimenter. An important component of the treatment was the selection of the appropriate colored overlays and trying them with various types of reading material. The selected overlays were then used by subjects in retaking the NDRT, which was administered at the end of the session. This process took 1.5 hours.

Group II - Reading Instruction/Control. These subjects were provided with traditional instruction in reading comprehension and study methods as outlined in the LAC Textbook Reading Study Skills Module. They were encouraged to use the skills they had just learned to take the NDRT posttest, which was administered at the end of the session. These sessions lasted approximately 1.5 hours.



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Subjects were then scheduled for a later session with the experimenter to do the IRPS screening.

Group III - No Treatment/Control. These subjects were informed that their treatment would be delayed until after taking the NDRT for a second time. They then took the NDRT posttest without receiving any treatment. This process took about 35 minutes. Students in Group III were then immediately offered the opportunity of participating in the IRPS screening procedure. This procedure demanded an additional hour.

Experimenters. The initial NDRT (pretest) and the Self-Test for SS/IS were administered to all subjects by trained professionals and paraprofessionals employed by the University Testing Center at Colorado State University. These instruments are noninteractive paper and pencil tasks with standardized administration procedures. The PASS screening was individually administered by personnel at the Learning Assistance Center who had been trained by a certified Irlen screener.

The treatment and posttesting sessions for all three groups of subjects were conducted solely by the author of the study. This experimenter was trained by Helen Irlen in July, 1997 to administer and interpret the IRPS. Training in using the Textbook Reading Study Skills Module and in administering the NDRT was provided by the Director of the LAC. Written protocols for the administration of the IRPS and the NDRT were consistently followed.



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Design and Data Analysis

A basic pretest/posttest design (Kazdin, 1992) was selected for this study and can be diagrammed as follows:

| | | | | |
|---|---|---|---|---|
| R | $O_1$ | $X_1$ | $O_2$ | Control Overlay/Experimental (Group I) |
| R | $O_3$ | $X_2$ | $O_4$ | Reading Instruction/Control (Group II) |
| R | $O_5$ | | $O_6$ | No Treatment/Control (Group III) |

Group assignment was blocked and random (R) by numerical rotation. The independent variables ($X_1$, $X_2$, or no treatment) were the three treatment conditions. The dependent variables (O) were the amount of improvement exhibited in pretest/posttest comparisons of NDRT Reading Comprehension and Reading Rate scaled scores for the three groups.

At the beginning of the study, all subjects scored in the high range for scotopic symptoms on the PASS ($\underline{M}$ = 42.3, $\underline{s.d.}$ = 9.5) and were blocked across groups to ensure equivalency of reading deficit level as measured by the NDRT. Except for the treatment conditions, all groups were exposed to similar experimental protocols within equivalent time frames and with the same experimenter.

Experimental Hypothesis I (see Figure 1a.) stated that the subjects who received treatment with colored overlays (Group I) would show significantly more pretest to posttest improvement on the NDRT Reading Rate measure than would the subjects who received traditional reading instruction (Group II) or subjects in the no treatment group (Group III). Experimental Hypothesis II posited that Group I would exhibit significantly more pretest to posttest



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improvement on the NDRT Reading Comprehension subtest than would Groups II or III (see Figure 1b.).

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Insert Figures 1a. and 1 b. about here

Therefore, an interaction effect between treatment condition and time was posited for both dependent variables. All groups were expected to begin with similar pretest scores for Rate and Comprehension and to improve somewhat over time due to practice effects. However, Group I was expected to show greater and statistically significant pretest to posttest improvement over the other groups. The significance of the Group x Time interaction effect for both measures was tested by repeated measures analysis of variance (ANOVA).



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# CHAPTER III

## Results

Subjects for this study were assigned to the following three groups or treatment conditions:

1) Group I - Colored Overlay/Experimental
2) Group II - Reading Instruction/Control
3) Group III - No Treatment/Control

These treatment conditions constituted the independent variable for the study. Posttesting on the Nelson-Denny Reading Test (NDRT) for Reading Rate and Reading Comprehension was completed immediately after subjects received their treatments. Measures of pretest/posttest improvement on Reading Rate and Reading Comprehension from the NDRT served as the dependent variables for the study.

Hypothesis I and Hypothesis II predicted that Group I would show statistically significant differential pretest to posttest improvement over the other groups on both dependent measures. Repeated measures analyses of variance were run to test significance for both hypotheses. These ANOVAS were specifically utilized to test the significance of the Interaction factor, Time x Group. Statistical information on the Within Subjects factor of Time was also obtained.

Prior to hypothesis testing, it was decided to determine whether subjects' pretest scores on the NDRT Reading Rate and Reading Comprehension measures were significantly related. Information regarding the relationship between these two variables



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has not been reported elsewhere, and rate and comprehension have been regarded as separate entities in the literature. In order to ensure that these two variables were independent and could therefore be tested separately, their correlation was examined.

Results of Pearson's Correlation indicated the correlation between the two sets of scores was moderate, $r = .34$, but nonsignificant, $p > .05$. Based on this correlation, the common variance shared by the two variables was approximately 12%, justifying separate analyses for Reading Rate and Reading Comprehension.

Hypothesis I - Reading Rate

Two statistical tests were performed to determine whether the data gathered for Hypothesis I met parametric assumptions. The results of Box's Test of Equality of Covariance Matrices (ACITS, University of Texas, 1997) indicated that the covariance matrices for the dependent variable Reading Rate, were equivalent across groups, $F$ (6, 18169) = 1.26, $p > .05$. The error variances of this dependent variable were also not significantly different across groups for either the pretest, $F$ (2, 27) = .788, $p > .05$, or the posttest, $F$ (2, 27) = 1.01, $p > .05$, as determined by Levene's Test of Equality of Error Variances (ACITS, University of Texas, 1997). Thus, parametric assumptions for homogeneity of variance and normality of distribution were met for the testing of Hypothesis I by a repeated measures ANOVA.

Mean standard scores for Reading Rate were not significantly higher on the pretest for Group I (Colored Overlays) than for the



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other two groups. All three groups improved their mean scores from pre to posttest. (See Table 1.)

Insert Table 1 about here

As illustrated by the repeated measures ANOVA results in Table 2, the only significant difference obtained for the dependent variable Reading Rate was produced by the Within Subjects variable of Time, Wilk's Lambda = 0.673, $F$ (1, 27) = 13.10, $p$ = .001. The Time x Group interaction was not significant, Wilk's Lambda = 0.956, $F$ (1, 27) = .927, $p$ > .05. All subject means, regardless of group, improved relatively equally over time. Therefore, the subjects receiving overlays did not improve their scores for Reading Rate significantly more than did subjects receiving traditional instruction or no treatment. Hypothesis I was not supported.

Insert Table 2 about here

Because significant F tests for Reading Rate were found only for Time and not for Time x Group, *post hoc* testing comparing specific groups on pretest and posttest data was not performed.

Hypothesis II - Reading Comprehension

Box's Test indicated that the observed covariance matrices of



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the dependent variable Reading Comprehension were statistically equivalent across groups, $F$ (6, 18169) = .632, $p$ > .05. Levene's Test of Equality of Error Variances showed the variance of Reading Comprehension scores was similarly equivalent across all three groups for the pretest, $F$ (2, 27) = .629, $p$ > .05, and for the posttest, $F$ (2, 27) = .155, $p$ > .05. Thus, parametric assumptions were met for the ANOVA testing of Hypothesis II.

Mean standard scores for the three groups on the Reading Comprehension pretest were virtually identical, showing the effects of randomization with blocking. (See Table 3.) Once again the means for all groups improved from pretest to posttest.

Insert Table 3 about here

However, unlike the results for Reading Rate, in this instance the repeated measures ANOVA indicated that there were significant effects for both Time, Wilk's Lambda = .437, $F$ (1, 27) = 34.73, $p$ < .001, and for the Time x Group interaction, Wilk's Lambda = .778, $F$ (2, 27) = 3.85, $p$ < .05. The latter result indicated that there was differential improvement on Reading Comprehension performance among the three groups, strongly suggesting differential treatment effects over time and thus providing support for Hypothesis II. (See Table 4.)

Insert Table 4 about here



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Because of the significance shown for the Time x Group interaction, *post hoc* testing was completed for Hypothesis II using the Scheffé Test for Multiple Comparisons to determine whether statistically significant differences could be found between specific groups. The following pairwise comparisons were run for both pretest and posttest Reading Comprehension means:

1) Group I to Group II.
2) Group I to Group III.
3) Group II to Group III.

The Sheffé Test performed on the pretest and posttest data for Reading Comprehension (see Table 5) showed no statistically significant differences in either pretest comparisons (expected, due to the randomized block design) or posttest comparisons (unexpected - refer to Table 4). Hypothesis II could not be specifically confirmed by the statistical data provided by the Sheffé Test.

Insert Table 5 about here

Summary of ANOVA Testing

From the significance testing described thus far, it is evident that all groups improved in Reading Rate, but there were no significant pretest/posttest differences between Groups I, II, and III. Therefore, as can be seen in Figure 2, using colored overlays did lead to some improvement in Reading Rate, but not enough to differentiate that treatment from reading instruction or no



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treatment. The only statistically significant improvement occurred for all groups equally, that is, the improvement over Time, possibly the result of practice effects.

Insert Figure 2 about here

In contrast to the Reading Rate results, however, significance testing for Reading Comprehension showed both general improvements for all groups over Time and a significant effect for the Time x Group interaction.

Insert Figure 3 about here

Although not detectable in *post hoc* tests, an examination of changes in mean scaled scores as depicted in Figure 3 indicates a trend toward greater improvement in Reading Comprehension for the colored overlay group than for the reading instruction or no treatment groups. In other words, there is some evidence to support Hypothesis II, that is, that colored overlays provided subjects with a performance advantage over other subjects. Groups I, II, and III improved their Reading Comprehension scores differentially over time, depending on which treatment they received. Figure 3 provides a visual depiction of where those differences lay. It illustrates that Group I showed greater improvement than either Group II or Group III.



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Since the mean for Group I clearly changed in the expected direction for Reading Comprehension and appeared to demonstrate more movement than the means for either Group II or Group III, it is probable that the lack of significance in the Sheffé posttest comparisons could be attributed to the lack of sufficient statistical power. This lack of power was most likely due to the small number ($n$=10) of subjects per group and the conservative parameters of the Sheffé test itself. In other words, with a sufficient number of subjects (e.g., $n$=25) per group, it is likely that significant posttest *post hoc* differences between groups would have been detected.



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# Chapter IV

# Discussion

## Reading Rate

The first hypothesis tested in this study predicted that the group receiving colored overlays would improve significantly more on Reading Rate from pretest to posttest than would groups receiving reading instruction or no treatment. This predicted improvement was not obtained. A repeated measures ANOVA did not indicate significant differential improvement from pretest to posttest when Time x Group data were analyzed.

One possible reason for this unexpected outcome may lie in the Reading Rate measure itself. Although the Nelson-Denny Reading Test is the preferred standardized test of silent reading skills developed for college level populations, its Reading Rate measure is extremely brief and cursory (i.e., a one-minute sample at the beginning of the test). Thus, it does not allow for the effects that fatigue may produce on reading rate over time. There is, therefore, no opportunity to evaluate subjects' habitual or mean reading speed over an extended period of time.

This becomes important when one considers that Irlen (1991) has stated that SS/IS symptoms increase in severity as the neurological mechanisms involved in reading become fatigued with sustained effort over prolonged periods of time. In fact, Irlen screening measures (1988, 1990) question subjects' subjective experiences "when you get to the point where you want to stop



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reading" (PASS and IRPS, Section I). Thus, testing reading rate during the first minute of reading may not adequately assess SS/IS effects on reading rate, nor the potential benefits of colored overlays on rate.

Since no other standardized measures of silent reading rate in adults besides the NDRT are available, it is difficult to speculate how this variable might have been more effectively measured. One possibility might be to establish local norms using the NDRT but utilizing a one-minute sample at the end of the allotted test period rather than at the beginning. This would allow for the fatigue factor, mentioned by Irlen and anecdotally reported in the literature (e.g. Bulmer, 1994), to have more of an impact on pre and posttest comparisons. Another possibility, again using local college populations to establish norms, would be to use an altogether different reading passage (e.g., an SAT practice passage) and count the number of words read over a specified and extended period of time.

These alternatives would not, of course, have the nationwide standardization and norming processes of the NDRT underlying them. Therefore, their usefulness in making scientific comparisons or generalizations would be limited. However, if enough subjects of different reading abilities were tested, it might be possible to determine a local (i.e., Colorado State University) distribution for such a redefined reading rate variable. Even if local norms were not established, subjects in studies similar to the current one could still be compared on amount of improvement over time using various treatments to increase reading rate raw scores on



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selected passages.

Results from other studies have produced mixed results when colored overlays or filters have been tested for their effect on reading rate. Several authors (Cotton & Evans, 1990; Gole et al., 1989; Robinson, Foreman & Dear, 1996) found no improvement in reading rate for subjects using colored filters. On the other hand, Kyd, Sutherland and McGettrick (1992), Kreutter and Strum (1990), O'Conner et al. (1990), and Gregg (1988) found significant pretest to posttest improvement on reading rate measures after subjects received either colored overlays or filters.

The above studies involved children or adolescents and measured oral reading rate. Robinson (1994) has suggested that differences in study outcomes may be related to factors other than SS/IS. He has posited that the difficulties some younger readers experience with phonetic analysis and word recognition, (crucial and required elements of oral reading) may also interfere with reading rate improvement. However, in the current study, since adults were tested on silent reading skills, it is less likely that phonetic analysis played a significant role in the failure to find improvement.

The only other known study, besides the current one, which has utilized standardized reading measures to test the effects of color (Irlen filters) on reading rate in adults was completed by Robinson and Conway in 1996. In measuring oral reading rate improvement, these researchers found statistically significant improvement in reading speed after three months of filter use for one experimental group. However, another experimental group (which received filters



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in a delayed manner) did not show improvement in rate after three months of use. Furthermore, improvement seemed to plateau for the former group at the three-month posttest, with no significant changes shown between three and six months.

Robinson and Conway hypothesized that perhaps the inconsistent reading rate results obtained in their study were due to the lack of phonetic analysis and synthesis skills in the adult population studied. They also postulated that efficient word identification skills were more developed in the upper quartile of their subjects chronologically (approximately 50 - 62 years old). Younger subjects (i.e., those in the lower quartile chronologically, ages 18 - 28) needed an average of five more minutes to complete reading passages in initial testing sessions than the older subjects did.

Despite Robinson and Conway's speculations concerning the impact of phonetic factors on rate, for the current study it is believed that, although phonetic analysis may have had some impact, it had less impact on silent reading rate than it would have on oral reading rate. In silent reading, not only can some unfamiliar words be skipped over without losing the thread of meaning (Bassin & Martin, 1976), but also the hesitation and embarrassment that may result from fear of mispronunciation or from repeated trials attempting to correct pronunciation may be, to some extent, eliminated. Leu (1981), in his review of oral reading error analysis, has theorized that oral and silent reading draw upon somewhat disparate subsets of skills. Visual skills and approximating word meaning from context may play a greater role in silent reading, while phonetic analysis and oral language skills



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may have more impact on oral reading.

Although it is intuitively compelling to believe that visual distortions would slow reading and that alleviating those distortions would speed reading, there is still no unequivocally convincing scientific evidence that this is true for adults in either oral or silent reading situations. This lack of evidence is somewhat puzzling and warrants further research.

In the current study, a major drawback was the brief length of the reading rate sample. One minute may be insufficient to measure either SS/IS symptoms or the impact colored overlays may have in alleviating those symptoms. Additionally, other factors besides visual perceptual distortion may contribute to reading rate problems, even in persons with severe SS/IS symptoms. It remains for future studies to find more effective ways of testing this variable in adults and to differentiate the impact that various perceptual, educational, and cognitive characteristics and treatments may have on it.

Reading Comprehension

The second hypothesis tested in this study predicted that the group receiving colored overlays would show significantly more pretest to posttest improvement on a measure of reading comprehension than would groups receiving reading instruction or no treatment. In this case, a repeated measures analysis of variance indicated there were significant Time x Group differences in pretest/posttest comparisons of the three groups. In other words, there was significant differential improvement over time, depending



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on group membership. Different treatments produced statistically different effects.

Because of the limited number of subjects and the conservative parameters of the Sheffé Test, *post hoc* testing was unable to detect any significant differences between groups in pairwise comparisons of posttest data. The Sheffé Test was not designed to test for interaction effects. Therefore, differential improvement between groups over time could not be tested. Group means at pretest and again at posttest were considered discretely. Since the Sheffé Test indicated no statistically significant differences between groups at pretest and no significant differences between groups at posttest, it was not possible to statistically determine precisely where the group differences indicated by the ANOVA testing were located.

However, the significant overall Time x Group differences found by the ANOVA testing for Reading Comprehension, combined with an examination of the changes in group means from pretest to posttest, offer strong indications that colored overlays provided a superior treatment modality to the other two methods, even though specific pairwise differences could not be confirmed as significant. It is likely that in a similar study using greater numbers of subjects, *post hoc* comparisons would prove to be significant in the direction predicted by Hypothesis II.

Robinson and Conway's (1996) adult study utilized another type of analysis which may have also provided more significant results for the current study. These authors tested within group differences, with paired *t*-tests for each group comparing pretest



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reading scores to scores obtained three and six months after treatment. They found no significant improvement in the control group over time for accuracy, rate, or comprehension. The "delay" experimental group achieved mixed results for accuracy, no significant results for rate, and significant improvement in comprehension for all three time frames. The "no delay" experimental group showed significant improvement over all time frames in accuracy and comprehension, but mixed results for rate.

However, paired t-tests cannot test the factor of time separately, so the influence of practice effects or maturation cannot be determined. They also do not allow the matrix of time by group relationships to be explored for multiple groups. Therefore, even if a significant t-test probability level had been achieved for the pretest/posttest comparison of the experimental (colored overlay) group in the current study, there would be no accurate statistical information on the effect of time alone and no comparative data combining Within and Between Group factors (Time x Group interactions) for all groups.

Several studies conducted with children have found significant improvement in reading comprehension with the use of colored overlays or filters (Chan & Robinson, 1990; Kreutter & Strum, 1990; McLachlan, Yale & Wilkins, 1993; O'Conner et al., 1990; Robinson & Conway, 1990; Robinson & Foreman, in press; Whiting, Robinson & Parrot, 1994; and Wilkins et al., 1994). Some have shown no improvement (Cotton & Evans, 1990; Gole et al, 1989; and Martin, MacKenzie, Lovegrove & McNichol, 1993). The mixed data evidenced by these studies may reflect the various designs and types of data



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analysis utilized, but a more parsimonious explanation for mixed outcomes may lie in the heterogeneity of causal factors related to dyslexia. Even when screened as positive for SS/IS, many of these younger subjects may have had several other factors contributing to their reading problems (Lovegrove, 1991).

None of the studies reviewed for this project, nor the current study itself, have systematically tested the connection between various attention, memory, visual processing, auditory processing, and language development factors in dyslexic youngsters or adults. Nor have the contributions these various processes make to reading comprehension been sorted out (e.g., in a path analysis design). Future research regarding both the etiology(ies) of dyslexia and the optimal treatment(s) for this disorder would be well served if more complex research designs, allowing for various combinations of factors, were implemented.

## Limitations

One limitation of this study was that, from the information presented on the consent form, subjects knew that the topics under investigation were Scotopic Sensitivity/Irlen Syndrome, its relationship to reading skills, and possible treatment modalities for SS/IS. Furthermore, it was not possible to control the amount of information subjects gained from other sources regarding SS/IS and its treatment. Therefore, some subjects entered the experimental condition with knowledge of the preferred (or publicized) mode of treatment, that is, the use of colored overlays or filters. Because only one experimenter designed the study and



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implemented all treatment groups, and because some subjects had previous access to pertinent information, this study could not be run as either a double-blind or single-blind experiment. There may have been expectations regarding preferred treatment mode and expected outcomes on both sides, although the experimenter was careful to present information to each treatment group in a positive, consistent, and hopefully unbiased manner.

The most obvious limitation of the study was the relatively small number of subjects, $N = 30$. Because there were only 10 subjects per group, differences between groups on the posttest measure for Reading Comprehension were not shown to be significant by *post hoc* testing, although the repeated measures ANOVA had indicated such differences existed. Additionally, any trends toward differential performance on the Reading Rate measure which might have been present in a larger sample were not suggested, even by the ANOVA testing.

Another issue related to both sample size and subject characteristics concerns the generalizability of the results. Since only 30 subjects participated, and all were white college students of average intelligence, caution must be exercised in applying implications derived from the study to other, dissimilar populations.

## Methodological Differences and Their Implications

Other than the current study, there is only one other known study (Robinson & Conway, 1996) which has collected and statistically analyzed quantitative data regarding the relationship



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of treatment for SS/IS to reading improvement in adults. As mentioned previously, that study included greater numbers of subjects who were reading at lower reading levels overall than the subjects tested for the current research project. Additionally, within groups t-tests were utilized for testing significance rather than repeated measures ANOVA's. Robinson and Conway, therefore, found stronger and more specific support for their hypotheses than did the current study. However, the repeated measures ANOVA results on the Reading Comprehension variable from the current study are reflective of the significant results found in all areas of reading for the "no delay" colored filter group by those authors.

Another difference between the current study and others is that other studies which have dealt with treatments for SS/IS and their impact on reading have completed posttesting several weeks or months after treatment implementation. Only the current study completed posttest measures immediately after treatment. It is possible that greater significance or a larger effect size could have been obtained with respect to improvement in Reading Comprehension variable if posttesting had been delayed. Subjects in the overlay group may have become more confident, more fluent, more comfortable, and more practiced in reading skills through overlay utilization over time than could be detected by immediate assessment.

The third difference observed between this study and similar studies is that the current research included a control group which received direct instruction on improving reading comprehension.



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Other studies have either had no control group (e.g. Robinson & Conway, 1990) or control groups which received lenses or filters not selected for optimal color (e.g., Robinson & Foreman, 1996). Thus, the design of the current study provided controls for placebo and Hawthorne effects, while also implementing a legitimate but alternative (not related to visual perception) treatment for reading deficits that could be expected to produce reading improvement.

By not using placebo colored filters (assumed to be of little therapeutic value if not of optimal color), but by providing reading instruction to improve comprehension, the test between groups (overlay vs. instruction) became even more stringent for this study than for others. In essence, this treatment was more than a "placebo," because it could be expected to produce favorable results beyond those related to positive expectations generated by merely receiving attention and/or by receiving an ineffective treatment. Therefore, future studies that use a similar experimental design with greater numbers of students could make some powerful assumptions about effectiveness of color for students with SS/IS, should *post hoc* testing show statistically significant improvements of the colored filter group over the reading instruction group.

## Suggested Modifications to Study

Modifications suggested for future projects investigating SS/IS and reading in college students, based on the limitations of the current study and other research, include the following:



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1) Test at least 25 subjects per group.

2) Create "single blind" subject conditions by omitting any mention of SS/IS from the referral process, consent forms, testing protocol, etc. Refer instead to "several experimental treatments that may possibly reduce some of your reading difficulties."

3) Use alternate reading test forms for pretest and posttest to control for practice effects.

4) Eliminate Reading Rate as a dependent measure or find a more meaningful way of testing it.

5) Test both silent and oral reading comprehension.

6) Add a control group of students who show the same severity of reading problems but who have few to no SS/IS symptoms.

7) Compare a group which takes the posttest immediately after treatment to a group which uses the overlays for several weeks and then is posttested. (Consider that there may be problems with confounding variables, history, inconsistency of overlay usage, attrition, etc. in doing so.)

8) Test subjects who have high scores for SS/IS symptoms on measures of auditory perception, decoding, encoding, etc. to see whether auditory perceptual problems are also present.

9) Test high scorers for SS/IS to see whether other visual perceptual or visual-motor problems are present.

10) Include a group that gets both treatments (e.g., colored overlays and reading instruction) prior to posttesting.

## Theoretical Implications

If improvement in reading comprehension for adults can be obtained with the use of colored filters, as suggested by the results of this study and several others (Bulmer, 1994; Irlen & Robinson, 1996; Robinson & Conway, 1996), it is important to understand why this occurs. It is possible, as implied by Blaxall and Willows (1984) that the majority of adults who are enrolled in college and reading at or above a high school level have more



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visually based problems with reading than auditorily based problems. If this is so, then treatments which address the correction of visual-perceptual distortions would be particularly helpful for this population. Also, older readers may have more developed comprehension tactics than children (such as guessing from context) and may be able to benefit immediately from color intervention rather than needing to practice over several weeks or months to acquire those strategies. In other words, color may enhance the capabilities already present in older readers, while it may merely assist younger readers in beginning to develop them (Robinson & Conway, 1996).

If full spectrum light processing abnormalities (Irlen, 1991) caused by abnormal distribution or functioning of rods and cones on the retina (Grosser & Spafford, 1989) is eased by color intervention for persons with SS/IS, then it could be expected that contrast glare, difficulty with bright or florescent lighting, and physical symptoms such as headaches and nausea might be reduced, thus freeing readers to clearly perceive and attend to the actual words and phrases before them.

Another possible cause for SS/IS which has been suggested is the malfunctioning of the magnocellular visual pathway in the brain, by which successive overlapping fixations are carried by the transient system, thus causing blurring, perceived print movement, and other types of visual distortions (Stuart & Lovegrove, 1992). If color, by some unknown neurological mechanism, mediates this process (Solman, Dain, & Keech, 1991), then fixations may become clearer, more distinct, and time-limited; while transitions may



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better serve the purpose for which they exist, i.e, getting from one visual object (or letter grouping) to another with maximum speed and minimum interference. Regressions, loss of place, and eyestrain might decrease; while print clarity and stability might increase.

Clinical Implications

Color mediated reductions in print distortions for adult readers, whatever the casual neurological mechanisms, may free them from the intense concentration otherwise needed to clarify print and recognize words. Their energy and attention may then be directed to higher level processes such as reading fluency, reading comprehension, and memory (Robinson & Conway, 1996). Support for this hypothesis comes not only from research on SS/IS and comprehension but also from research showing fewer fixations and regressions, and thus smoother and more consistent eye movement, in SS/IS sufferers when using colored filters (Tyrell et al., 1995).

One possible clinical implication for college students who are diagnosed and treated for SS/IS is that, as visual distortions and accompanying symptoms are reduced, the ease and comfort of reading may increase. These effects might encourage students to read more, thus improving their knowledge and retention of content area information and, by extension, their grades. Also, as fluency and comprehension increase with practice, reading may cease being the tortuous experience some of these students describe. Reading for pleasure may become a possibility for the first time.



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A caveat should be mentioned here, however. Since there are numerous causes for reading difficulties in both children and adults, treatment for SS/IS would rarely be expected to "cure" a specific individual's dyslexia (Irlen, 1991). Poor phonological skills, limited vocabulary, language processing problems, poor short-term memory, attention deficits, lack of reading experience, and inefficient reading strategies are only some of the other factors that may interfere with reading skills development. Unless these issues are also considered, assessed, and addressed when working with persons who have reading disabilities, it is unlikely that colored overlays or filters alone will have maximal impact for most students.



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## Summary and Conclusions

The results of the current experiment offer some intriguing evidence that colored overlays and/or filters may have an impact on the visual perceptual condition which has been labeled Scotopic Sensitivity/Irlen Syndrome. Results showed that the three groups improved differentially over time in Reading Comprehension depending on which treatment was provided to subjects. Although significance for pairwise comparisons was not found because of power issues, data appear to indicate that the colored overlay group achieved a higher level of improvement than the other two groups. Data for the variable of Reading Rate seemed less impressive, showing no significant differential improvement on the repeated measures ANOVA.

The current study found that overlays provided immediate improvement in Reading Comprehension for some adult readers. Further controlled studies should be instigated to determine whether such improvement continues and possibly gains potency over several months or years of overlay or filter usage. Other methods of assisting adults with dyslexia may need to be combined with SS/IS treatment to produce optimal effects. Studies should also be conducted to explore the etiology, definition, prevalence, comorbid conditions, treatment, and outcomes for SS/IS in adult populations.

There are several hundred school districts nationally (Irlen Institute, 1999) which provide screening for SS/IS as a service for the children in public schools. The local school district, Poudre R-1, instituted a screening program in the Spring of 1989 (Crymble, 1990). Today at least one professional per school building is



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trained in SS/IS screening procedures. The district also provides funds for screening materials and one set of overlays per year for identified students. With increased data available on adult populations, perhaps colleges, universities, training programs, and workplaces will find it cost effective and beneficial to provide screenings for interested students and employees as well.

Miller (1984) found that 15% of his "high ability" subjects tested positive for SS/IS, and 73% of his "LD" subjects tested positive. Robinson, Hopkins, & Davies (1995) found in screenings of several hundred high school students that approximately 20% of the general student population may have moderate to severe symptoms of SS/IS. The current author's 1996 pilot study found that 13% of normal readers in the college population sampled showed such symptoms; while 75% of the students with reading problems evidenced moderate to severe symptoms of SS/IS. Any procedure which can assist both nondisabled and disabled college level students to read more efficiently and effectively and which is relatively cost-effective deserves further scientific and clinical attention.

It is ironic that for many lay persons the word "dyslexia" elicits an immediate correlation with visual reversals in reading, spelling, and handwriting. In the past, reading disabilities were often linked to abnormal visual perception. Samuel Orton (1937), the first neurologist to investigate dyslexia, called visual distortions "strephosymbolia" which translates as "twisted symbols." Spache (1976) stated that reading was "highly dependent" on visual intake and that comprehension was therefore significantly influenced by visual perception. Much of the more recent research



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and theory regarding dyslexia, however, suggests that auditory and language-based mechanisms are responsible. Perhaps the time for a more comprehensive view of dyslexia has arrived. Hopefully studies of SS/IS and visual perception will help to broaden the field of research on dyslexia to include all aspects of biological, neurological, psychological, and environmental functioning which may impact this complex learning disorder.



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Table 1

Means, Standard Deviations, and n: Reading Rate

| | | Group | Mean | Std. Dev. | n |
|---|---|---|---|---|---|
| Pre test | I. | Colored Overlays | 187.50 | 17.16 | 10 |
| | II. | Reading Instruction | 183.60 | 9.05 | 10 |
| | III. | No Treatment | 174.40 | 14.58 | 10 |
| | | Total | 181.83 | 14.62 | 30 |
| Post test | I. | Colored Overlays | 199.40 | 18.55 | 10 |
| | II. | Reading Instruction | 188.80 | 15.16 | 10 |
| | III. | No Treatment | 180.70 | 17.28 | 10 |
| | | Total | 189.63 | 18.21 | 30 |



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Table 2

Repeated Measures Analysis of Variance: Reading Rate

| Effect | Wilks' λ | SS | df | MS | F | p |
|---|---|---|---|---|---|---|
| Time | 0.673 | 912.60 | 1 | 912.60 | 13.10 | < .001 |
| Time X Group | 0.936 | 129.10 | 2 | 64.55 | 0.93 | .408 |
| Error | | 1880.30 | 27 | 69.64 | | |



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Table 3

Means, Standard Deviations, and n: Reading Comprehension

| | | Group | Mean | Std. Dev. | n |
|---|---|---|---|---|---|
| Pre test | I. | Colored Overlays | 189.40 | 18.58 | 10 |
| | II. | Reading Instruction | 191.30 | 13.94 | 10 |
| | III. | No Treatment | 191.60 | 16.54 | 10 |
| | | Total | 190.77 | 15.91 | 30 |
| Post test | I. | Colored Overlays | 213.20 | 19.68 | 10 |
| | II. | Reading Instruction | 199.60 | 19.27 | 10 |
| | III. | No Treatment | 202.60 | 22.00 | 10 |
| | | Total | 204.58 | 20.40 | 30 |



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Table 4

Repeated Measures Analysis of Variance: Reading Comprehension

| Effect | Wilks' λ | SS | df | MS | F | p |
|---|---|---|---|---|---|---|
| Time | 0.437 | 3096.02 | 1 | 3096.02 | 34.73 | < .001 |
| Time X Group | 0.778 | 685.63 | 2 | 342.82 | 3.85 | .034 |
| Error | | 2406.85 | 27 | 89.14 | | |



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Table 5

Scheffé Test of Multiple Comparisons: Reading Comprehension

| | (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | p |
|---|---|---|---|---|---|
| Pre Test | I | II | -1.90 | 7.364 | .97 |
| | | III | -2.20 | 7.364 | .96 |
| | II | I | 1.90 | 7.364 | .97 |
| | | III | -.30 | 7.364 | .99 |
| | III | I | 2.20 | 7.364 | .96 |
| | | II | .30 | 7.364 | .99 |
| Post Test | I | II | 13.60 | 9.10 | .34 |
| | | III | 10.60 | 9.10 | .52 |
| | II | I | -13.60 | 9.10 | .34 |
| | | III | -3.00 | 9.10 | .95 |
| | III | I | -10.60 | 9.10 | .52 |
| | | II | 3.00 | 9.10 | .95 |



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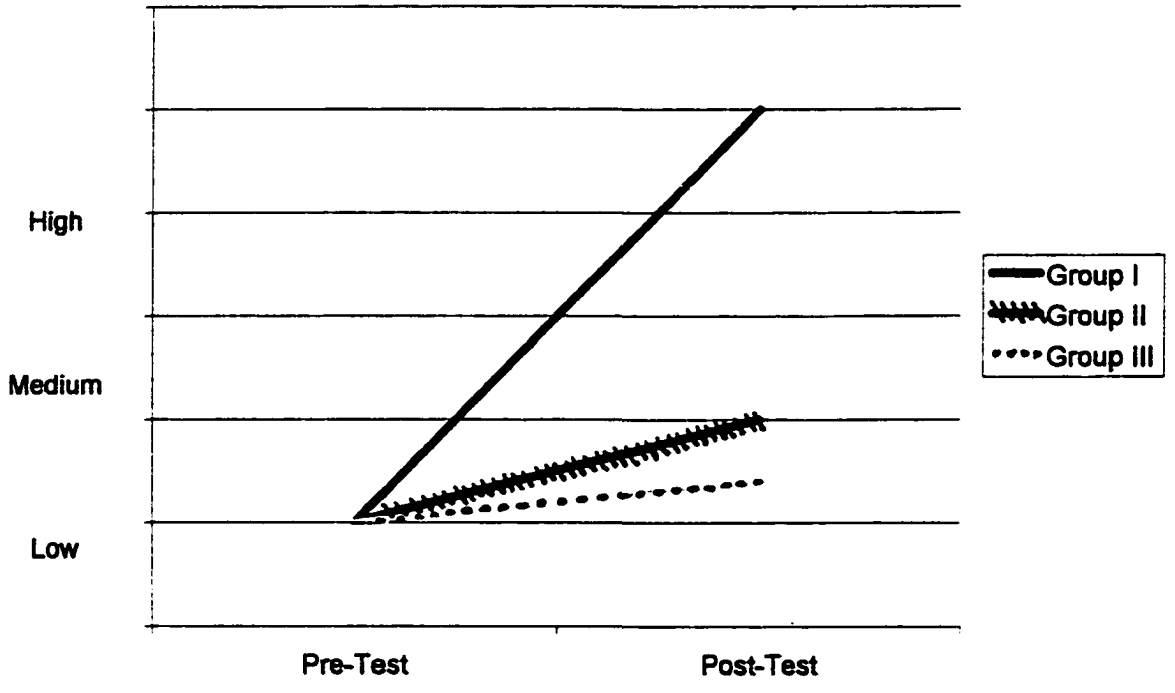


Figure 1a. Hypothesized improvement in Reading Rate for Groups I, II, and III.

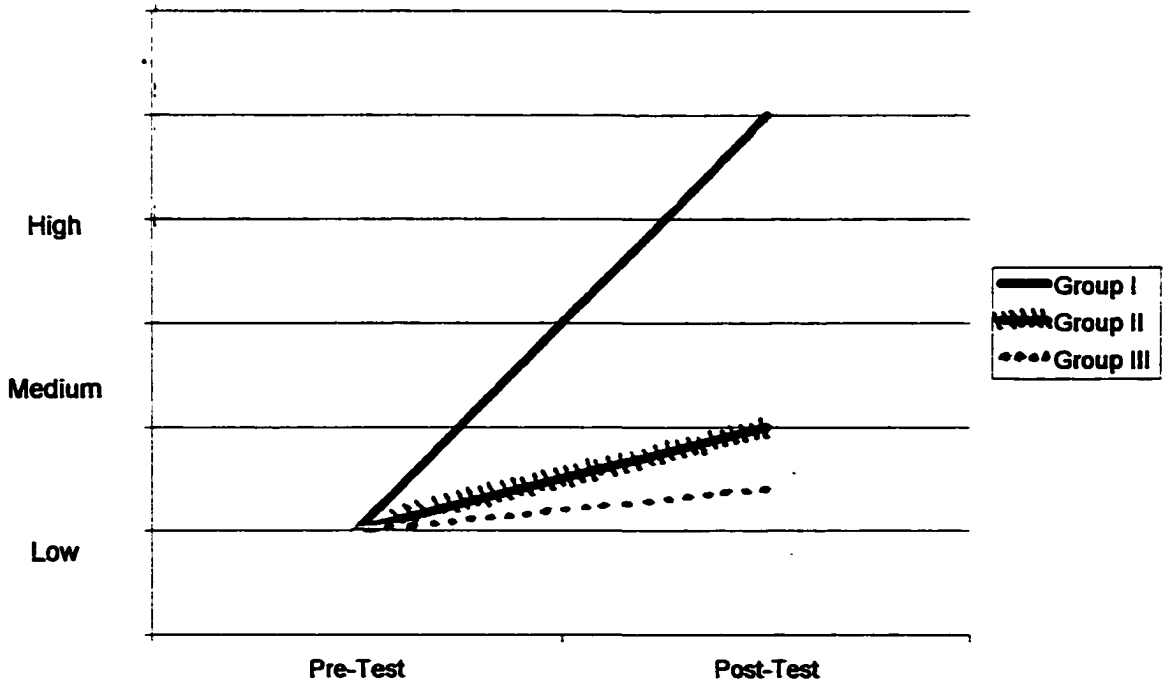


Figure 1b. Hypothesized improvement in Reading Comprehension for Groups I, II, and III.



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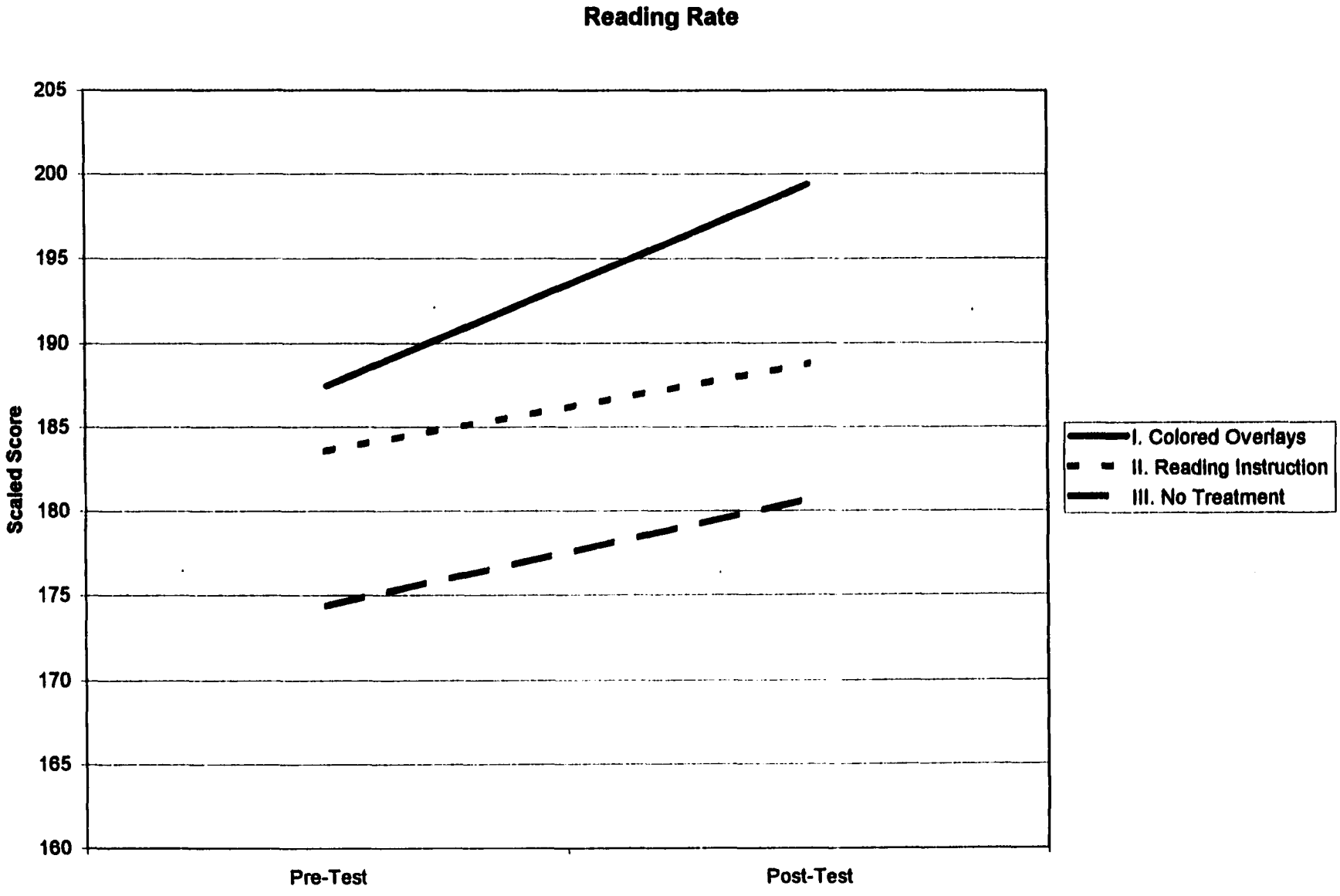


Figure 2. Comparison of Reading Rate improvement for Groups I, II, and III.



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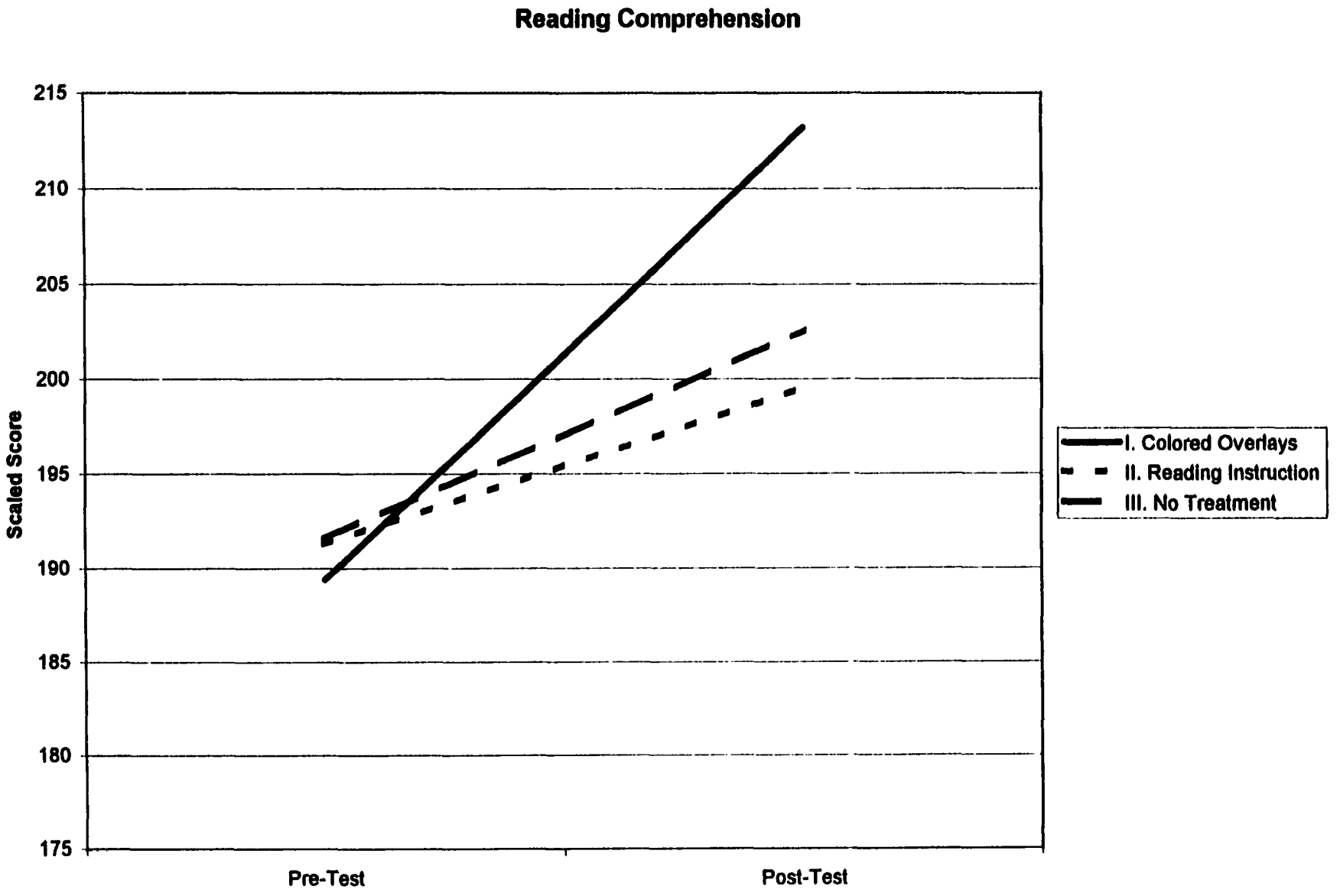


Figure 3. Comparison of Reading Comprehension Improvement for Groups I, II, and III.



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## APPENDIX: Raw Data

| SUBJECT # | GROUP # | COMPREHENSION PRETEST SCALED SCORE | READING RATE PRETEST SCALED SCORE | COMPREHENSION POSTTEST SCALED SCORE | READING RATE POSTTEST SCALED SCORE |
|---|---|---|---|---|---|
| 1 | 3 | 182 | 164 | 185 | 195 |
| 2 | 1 | 188 | 171 | 226 | 188 |
| 3 | 2 | 176 | 198 | 183 | 218 |
| 4 | 1 | 182 | 180 | 232 | 208 |
| 5 | 3 | 188 | 166 | 182 | 159 |
| 6 | 3 | 185 | 166 | 198 | 171 |
| 7 | 2 | 207 | 175 | 204 | 166 |
| 8 | 3 | 182 | 166 | 198 | 166 |
| 9 | 2 | 198 | 183 | 201 | 180 |
| 10 | 1 | 213 | 228 | 229 | 228 |
| 11 | 1 | 194 | 180 | 207 | 213 |
| 12 | 2 | 204 | 193 | 232 | 204 |
| 13 | 1 | 169 | 193 | 204 | 204 |
| 14 | 3 | 163 | 166 | 166 | 164 |
| 15 | 2 | 194 | 175 | 182 | 183 |
| 16 | 3 | 216 | 193 | 235 | 193 |
| 17 | 1 | 176 | 166 | 179 | 175 |
| 18 | 2 | 182 | 188 | 207 | 201 |
| 19 | 1 | 157 | 183 | 185 | 183 |
| 20 | 3 | 210 | 180 | 232 | 204 |
| 21 | 1 | 201 | 188 | 238 | 183 |
| 22 | 3 | 210 | 180 | 219 | 193 |
| 23 | 1 | 213 | 188 | 216 | 188 |
| 24 | 2 | 204 | 193 | 210 | 193 |
| 25 | 3 | 198 | 159 | 201 | 164 |
| 26 | 1 | 201 | 198 | 216 | 224 |
| 27 | 2 | 194 | 180 | 201 | 183 |
| 28 | 2 | 191 | 180 | 213 | 180 |
| 29 | 3 | 182 | 204 | 210 | 198 |
| 30 | 2 | 163 | 171 | 163 | 180 |



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