

## Reading Disabilities and the Effects of Colored Filters

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*The efficacy of a controversial treatment, using colored filters to remediate reading disabilities, was measured empirically, with colored overlays placed over reading material on white paper. Irlen's (1983) method is to prescribe specific tinted filters as lenses that she claims filter specific light frequencies and remove a range of perceptual disorders that adversely affect reading and related learning performance. Irlen calls this condition "scotopic sensitivity" and claims it is a significant factor in a high percentage of people with learning disabilities. Ninety-two children with significant reading disabilities were classified as either scotopic or nonscotopic using the Irlen Differential Perceptual Schedule, and were randomly assigned to one of six treatment groups using colored or clear overlays. Reading performance (rate, accuracy, and comprehension) as measured by the Neale Analysis of Reading Ability (Neale, 1987) and the Formal Reading Inventory (Wiederholt, 1986) improved significantly when the scotopic children read with the preferred colored overlay filter compared to clear or different-colored overlay filters. Nonscotopic children showed no change.*

The field of reading disabilities is replete with methods of remediation. Over the years many of these approaches have been hailed as major breakthroughs, and some still have their staunch advocates. Most of these approaches have not stood the test of rigorous research analysis, or they are at best controversial, comprising clinical but not experimental evidence (Myers & Hammill, 1976, 1982; Silver, 1987; Wyne & O'Connor, 1979).

As Silver (1987) pointed out, the danger is that parents and professionals latch onto these methods as "magic cures," and the techniques become popular without adequate scientific evidence. Many of these approaches have focused on visual-perceptual aspects of learning disabilities; for example, Kavale's (1982) review of the relationship between visual-perceptual skills and reading achievement using the meta-analysis statistical technique raised the issue of the proportion of variance in reading performance that can be attributed to visual-perceptual skills. Meanwhile, significant reading disabilities persist in an alarmingly high percentage of children and adults, most of them unexplained in terms of sensory or intellectual deficits. While some reading problems may have resulted from poor teaching,

this would seem to be an unsatisfactory explanation for the numbers involved.

### SCOTOPIC SENSITIVITY

Clearly, reading disability is a multifactorial problem. Irlen's (1983) research, involving adults with a long history of reading problems who were enrolled in community-college-level courses, has led to investigation of a new theory that purports to account for a significant proportion of reading disabilities. Irlen claimed to have diagnosed a cluster of symptoms related to a perceptual disorder not diagnosed by optometric examinations; she called this disorder "scotopic sensitivity." Irlen's concept is that many children and adults with reading disabilities and other perceptual problems that remain uncorrected are highly sensitive to particular frequencies and wavelengths of the white-light spectrum. These specific light frequencies are purported to cause fatigue and trauma to the visual system and result in a number of problems, such as reading disabilities, poor coordination and depth perception, sore eyes, high sensitivity to glare, and rapid fatigue when reading. Irlen noted a strong familial history of similar reading problems

accompanied by similar symptoms among the adults with reading disabilities in her study.

According to Irlen (1983), the major symptoms of scotopic sensitivity include

- Rapid fatigue after very little reading, with marked deterioration in reading performance and concentration;
- Eye strain after a short time, with symptoms of itchy eyes, watery eyes, aching eyes, stinging eyes, gritty sandy eyes, or frequent blinking and squinting. These symptoms are sometimes mistaken for allergies;
- Frequent skipping of whole lines or words and frequent retracking, resulting in hesitant reading;
- Distortions of print on white paper. This may include letters distorting in shape, marked reduced space between words, words running together "like runny ink," parts of words or whole words missing, or words spinning backwards;
- Movement of the print in a shimmering, wavering, vibrating, or fluorescent effect;
- Swirling of the print on white paper after a short period. This can be a swirl of the whole page of print like a whirlpool, or spinning of individual words. Some children actually read better right to left with the print upside down;
- Seeing streaks of white or colored lines through and between the print, often described as rivers or tracks;
- Rapid blurring of the print despite the reader having normal vision;
- Seeing doubling of the print as ghosting of letters—white or gray double images;
- Seeing gray shadows or bright circles of light like halos around letters and words;
- Restricted visual span, similar to tunnel vision, such that they see only one word or half a long word at a time. This is often apparent from reading one word at a time;
- Headaches from reading under fluorescent lighting, or reaction to glare;
- Red and watery eyes after reading for a while or as a reaction to glare;
- Requiring tremendous effort to concentrate, with low levels of attention and avoidance of reading when possible;

- Poor depth perception, apparent in poor ball skills, lack of confidence in descending stairs or escalators, and judging spaces between objects in one's environment (e.g., walking through doorways, judgment in driving).

It should be stressed that Irlen does not state that all these symptoms need be present, yet a cluster of these symptoms persists despite repeated eye examinations and prescription of mild stress lenses.

The Irlen technique involves eliminating all the symptoms that fatigue the visual system by prescribing precisely colored lenses to filter out the offending light frequencies. According to Irlen (1983), this precise color filter, if placed in lenses over the eyes, results in improved visual perception (particularly improved reading ability) and ability to read for much longer periods, as well as eliminating other distressful symptoms, such as headaches and poor depth perception.

The initial reaction of many professionals to Irlen's thesis has been understandably and predictably skeptical—indeed, quite critical and negative in some cases. For example, the Australian College of Ophthalmologists issued a one-page statement as a press release in 1987, expressing opposition and warning people that there was no basis from an ophthalmologic viewpoint to justify treatment with colored lenses for reading disabilities. If Irlen is correct, it is conceivable that many children and adults who would normally be prescribed corrective lenses for reading disabilities and for exhibiting some of these symptoms might benefit more from a different treatment.

### RECENT RESEARCH ON EFFICACY OF IRLÉN COLORED FILTERS

While Irlen's (1983) technique is very new, there is extant research on its efficacy. Miller (1984) analyzed the responses of high and low reading ability community college students in Hawaii using the Irlen screening procedures for scotopic sensitivity. Seventy-four percent of the low ability readers were diagnosed as having scotopic sensitivity, while less than 15% of the high ability readers

showed any signs of scotopic sensitivity. Analysis of the responses to the screening tests indicated a significant difference between the high and low readers on the various symptoms of scotopic sensitivity. These results were very similar to Irlen's (1983) findings with adult students in California. Ament, Carrier, and Salmon (1987) reported highly positive reactions of 87% of parents and 63% of teachers to the effects of the Irlen lenses with 20 children in the Northern Territory, Australia. Although the size of the group was small, the positive reaction of the teachers to the effects of the Irlen lenses was significant because initially most of the teachers were skeptical.

Adler and Atwood (1987) investigated the effects of Irlen tinted lenses on both academic performance and career success with secondary students in Los Angeles County. A sample of 50 students selected from 330 remedial and special education students at two large high schools was diagnosed as high in scotopic sensitivity by the Irlen Institute in Los Angeles. The research was then conducted independent of the Irlen Institute by staff of the Regional Occupational Program in the East San Gabriel Valley. On the basis of the visual problems diagnosed, the students were ranked and then assigned evenly to either the experimental or comparison group. The groups were then pretested on four academic tests of the General Aptitude Test Battery (GATB), namely General Learning Ability, Verbal Ability, Numerical Ability, and Spatial Ability. There was no statistical difference between the experimental and comparison groups on any of the academic pretesting. Students in the experimental group were then each given individually prescribed Irlen tinted lenses. Both experimental and comparison groups were enrolled in a General Merchandising class that was part of the Regional Occupational Training Program offered to high school students. The experimental and comparison groups were then posttested on a number of factors, including visual problems and performance tasks. In all areas, the differences between the experimental and comparison groups were substantial, and all statistically significant beyond the .01 level. In terms of career potential, half the experimental group were employed by the end of the Project,

while none of the comparison group were employed.

Robinson and Miles (1987) measured the changes in performance on a number of reading tasks with 40 children with reading problems who were divided into three groups according to their degree of scotopic sensitivity. Each child was tested on the reading tasks with three different colored overlay sheets, one being the "best" color for that child to minimize visual problems, another being a random color, and another being a clear sheet. Results demonstrated that performance on reading tasks (such as word matching and letter recognition) was enhanced by the correct colored overlay. Subsequent research was conducted by Robinson and Conway (this issue) with 44 children with reading difficulties who were considered scotopic in terms of the Irlen Differential Perceptual Schedule (IDPS) (Irlen, 1983). The students were prescribed Irlen tinted lenses according to the Irlen methodology, after initially using colored overlays and, for a short time, using lenses tinted to match the preferred colored overlay. Robinson and Conway (this issue) reported a 3-year gain in reading comprehension in the 1-year duration of the study. They concluded that, allowing for other factors, at least 2 years of this gain could be reasonably attributed to the effects of the Irlen colored lenses.

Whiting and Robinson (1988) reported results of a clinical survey of 224 people who had worn the Irlen lenses for more than 12 months. More than 90% reported improvement in reading fluency and ease of reading; 84% reported improvement in reading comprehension; more than 80% reported greater concentration, less eye strain, and far less loss of place and visual confusions; 68% reported improvement in spelling; and 58% reported improvement in handwriting. Other research supports Irlen's work and illustrates both improved reading performance with tinted lenses and prevalence of the scotopic sensitivity syndrome among college students (Murphy, 1985; Pascoe, 1986).

A recent article reported research by a team comprising psychologists, ophthalmologists, and optometrists (Hannell et al., 1989). It provides clear supporting evidence for the positive effects of tinted lenses on reading and writing skills for children with dyslexia. Among other find-

ings, the study described significant visual distortions when the subjects were looking at print on white paper, which the researchers claimed suggests that "the area of reading disability must therefore look beyond a purely psycholinguistic interpretation of reading" (Hannell et al., 1989, p. 175).

However, there are some studies reported in the literature that question the efficacy of colored filters to remedy reading disabilities. Stanley (1987) reported the results of a study that he believed raised serious doubts about the genuine effects of colored filters on reading performance, and he concluded that what temporary effects might be demonstrated were probably attributable to placebo or motivational effects that were not sustainable. This study involved 16 students, with no control group, who were required to select a colored overlay from among four possible colors and use this overlay for 6 weeks. Stanley acknowledged in the article that he did not assess the students in terms of the symptoms of scotopic sensitivity.

Winter (1987) reported the results of a study with 15 students using a letter-identification task under four conditions, with speed and accuracy of letter identification the dependent variables. The four conditions were (a) wearing Irlen lenses, (b) wearing plano clear lenses, (c) wearing plano gray-tinted lenses, and (d) wearing no lenses. Winter found no significant differences among the groups. Saint-John and White (1988) reported a similar study with 22 students, 11 experimental (reading disabled children) and 11 control children. The mean reading age difference between the groups was 36 months. The conditions were with children wearing frames without lenses, polaroid (placebo) lenses, and colored overlay transparencies, selected from six colors. No effect was found in favor of the group with the colored transparencies.

The purpose of the present study was to test the efficacy of the relationship between reading disabilities and scotopic sensitivity in such a way as to control for most of the factors usually cited by critics of research on the Irlen lenses, including independence of the reading assessors, use of double-blind testing procedures, testing effects, maturational factors, and placebo/motivational effects.

## METHOD

### Subjects

Teachers were asked to nominate students from Grades 2 to 6 who were reading at least 18 months below grade level and whom they considered to have reading ability well below their abilities in other areas. Prior to nominating the children, the teachers attended staff meetings at which presentations on the nature of scotopic sensitivity were given. This was done to ensure that teachers did not refer students of low overall intellectual ability and to enlist their cooperation with the study. The teachers nominated 105 children, drawn from a total population of 600, in Grades 2 to 6 (age range 8 to 12 years) attending two large elementary schools in middle socioeconomic class suburban areas of a medium-sized Australian city. All the children were English-speaking Australian children. All were within the average to above average intellectual range based on school records of group intelligence scores (mean IQ level = 109; range = 92 to 129). Of the 105 children nominated, all were in regular mainstream classes with the exception of two 8-year-olds who were in a Junior Assistance Class. The Junior Assistance Classroom concept in this school system serves young children identified at 6 years as having ability but being at risk for learning disabilities if left without special assistance in the mainstream classroom during their early years of school. The school system does not have special classes for students with learning disabilities (LD). Such students are served by the resource teacher model in the regular classroom; and the categorical label of learning disability is not used. While it would have been easier to drop these two students from the group because only one IQ measure on them was available and they tested at the bottom of the IQ range for the group, the concern expressed by the teachers regarding the unexplained poor school performance of these two children and their uneven learning profile led to their inclusion. Fifty-two children of the nominated group had had previous optometric assessments and were not prescribed corrective lenses. Ten children had corrective lenses, and 15 had low-powered

stress lenses (i.e., mild magnification with no other correction). All the children had been assessed during the visual screening conducted on all school children in Grade 1 by the Community Health Service.

### Procedure

All children were screened individually for signs of scotopic sensitivity using the Irlen Differential Perceptual Schedule (IDPS) (Irlen, 1983) and were screened for defective color vision using the Ishihara Tests for Color-Blindness (Ishihara, 1973). The screening procedure with the IDPS involves a series of perceptual tasks on white paper followed by a reading assessment. Students who displayed definite scotopic signs and displayed marked improvement in reading performance with a particular colored transparency overlay were classified as scotopic. Students who did not show scotopic signs were classified as nonscotopic. None of these students showed any change in reading performance with the colored overlay sheets. Sixty-seven children were considered scotopic and 25 were considered nonscotopic. Among the 67 children considered scotopic, 45 were boys and 22 girls. The 25 nonscotopic children comprised 14 boys and 11 girls. Thirteen of the 105 children showed a few scotopic signs but did not show any preference for color and showed no relief from visual disorder or reading improvement with any of the colored transparencies. These children were dropped from the sample for the study because it was thought their visual problems may have been due to uncorrected optometric problems. It was not possible to delay the study to wait until these students had been tested and possibly prescribed new optometric lenses. (Subsequently, 8 of these children were prescribed corrective lenses, and 4 were given low-powered stress lenses.) This left a sample of 92 children who averaged 2.1 years below grade level in reading ability. Twelve of the scotopic children were color defective, and 1 of the nonscotopic group was color defective. See Table 1 for a summary of sample details.

In order to control for factors such as testing effects, placebo effects, motivational effects, and double-blind proce-

dures in the actual testing, children were randomly assigned to one of six groups in an expanded Solomon Four design (Campbell & Stanley, 1963). The scotopic children were randomly assigned to one of four treatment groups, consisting of 17, 17, 17, and 16 children (Groups A, B, C, and D, respectively). The non-scotopic children were randomly assigned to two treatment groups, consisting of 12 and 13 children, respectively (Groups E and F). The allocation consisted of a stratified randomization procedure ensuring that all groups consisted of an approximately equal number of children from each grade level, 2 to 6 (see Table 1).

Groups A, B, C, E, and F were pretested and then posttested a week later using the Neale Analysis of Reading Ability (Forms A and B) and the comprehension section of the Formal Reading Inventory (Forms A and C) (Wiederholt, 1986). Group D was posttested only in order to control for possible testing effects. All reading assessments were conducted by a research assistant and two teachers enrolled in a graduate course in special education. None of the reading assessors knew which children were scotopic or non-scotopic; nor were they aware of the research design or which children had been allocated to the various treatment groups. As part of the scotopic screening, the best colored transparency

(i.e., the color that eliminated most symptoms, gave clearest vision, and most improved reading fluency) was determined for each scotopic child. After the reading pretest, each child in Group A was given a colored transparency that matched the individually preferred color; children in Groups B and D were given a clear transparency; children in Group C were given a colored transparency other than the individually preferred color. Similarly, the non-scotopic groups were assigned transparencies. Group E children were given clear transparencies, and Group F children were each given a randomly selected colored transparency from an assortment of 10 colors. As the children were given the transparency sheets they were asked to use them over the white paper for all reading activities (including math tasks) for 1 week, and were told, "We think this might make reading a little easier for you."

The children had the transparency overlays for 1 week and were encouraged to use the sheet over all reading material for both schoolwork and homework. Teachers ensured that this happened in class, and parents were asked to assist with supervision at home. After 1 week, the children were then retested in reading on both tests by independent assessors. For these assessments, the children used their respective overlay transparencies.

## Assessment Instruments

The screening procedure to determine whether a student was scotopic or non-scotopic was conducted with the IDPS. The IDPS involves a series of perceptual tasks on white paper followed by a reading assessment. Scotopic students will display several of the scotopic signs listed earlier, while non-scotopic students do not. The IDPS yields a measure of severity upon which degree of scotopic sensitivity may be judged. The perceptual tasks consist of the following:

1. Two separate cubes divided into smaller boxes with good contrast of black ink on white paper. The students are required to count a specified column of small boxes within the cube without using a finger or marker.
2. Students are required to count a horizontal row of percentage symbols embedded in a larger geometric design consisting of percentage symbols, with good contrast of black on white paper.
3. Students are required to look at three sets of music staves divided into three segments by two bar lines, with one black note in the middle of the "B" line of the middle staff. While looking at the "B" note on the middle staff, students are asked a series of questions about their quality of perception. Particular care is taken to ensure that questions are framed to allow several possible responses (e.g., "Do the music lines appear to be straight or wavy?" "Are they moving or still?" and so forth).
4. Students are required to look at a page of high quality black print on good quality white paper. Students are asked to look at the sheet and respond to a series of questions about the quality of print they see, the spacing of the print, the comfort of looking at the sheet, and so forth.

With students who displayed clear signs of scotopic sensitivity, a range of 10 colored transparency sheets were placed one at a time over the music lines and the page of quality print to ascertain whether any relieved the symptoms and distortions. The two preferred colored transparencies were selected to be used

TABLE 1  
Summary of Group Chronological Ages, Sex, and Pretest and Posttest Reading Ages

Groups	A (n = 17)	B (n = 17)	C (n = 17)	D (n = 16)	E (n = 12)	F (n = 13)
$\bar{X}$ Age	10.4	10.2	10.3	10.7	10.1	10.2
Age range						
8 to 9 yrs	5	4	6	2	2	3
10 yrs	4	6	5	9	5	4
11 yrs	5	5	4	2	4	4
12 yrs	3	2	2	3	1	2
Males (n)	10	13	10	12	8	6
Females (n)	7	4	7	4	4	7
$\bar{X}$ pretest reading age						
Neale Rate	8.1	8.3	8.3	—	8.0	7.11
Neale Accuracy	8.0	8.2	8.1	—	7.11	8.0
Neale Comprehension	7.11	8.2	8.2	—	8.1	8.2
FRI Comprehension	8.0	8.2	8.3	—	7.11	7.10
$\bar{X}$ posttest reading age						
Neale Rate	8.8	7.11	8.1	8.0	7.11	7.9
Neale Accuracy	8.7	7.11	8.1	8.2	7.11	8.1
Neale Comprehension	9.6	7.8	8.2	7.10	8.0	8.4
FRI Comprehension	9.4	7.9	8.3	7.11	7.10	7.10

Note. FRI = Formal Reading Inventory.

with the reading assessment. The student was required to read a sample of reading material at his or her comfortable reading level; he or she was required to read for some time with just the white paper, and then read on with each of the two preferred colored transparency overlays.

The main symptoms watched for during the scotopic screening were (a) clear signs of visual distress with watery, burning, itchy eyes, or reporting of sore eyes; (b) inability to count accurately without resorting to the use of a finger or marker; (c) reported distortion of the music lines, movement of the lines, blurred vision looking at the lines, doubling of the lines, disappearance of parts of the lines; (d) reported movement of the print, blurred vision when looking at the print, print reported as being squashed or run together, swirling of print, shadows or ghosting of the print, and so forth; and (e) clear improvement in reading performance with the preferred colored transparency, including fluency, less skipping of words or lines, and less discomfort in the eyes while reading.

The Neale Analysis of Reading Ability (NARA) consists of six passages of prose forming a continuous reading scale for children aged 6 to 13 years. Each passage is a complete narrative suited to the interests of the age level to which it is assigned. There are eight comprehension questions to each of the passages, except in the case of the first passage, where there are only four. There are three parallel forms of the test, Forms A, B, and C. Age norms are provided for reading rate, accuracy, and comprehension. Each passage is accompanied by a picture designed to set the scene and be relevant for each narrative. Students are required to read the passages orally at increasing levels of difficulty until they reach the ceiling level of errors (Neale, 1987). After reading each passage orally, a series of comprehension questions are asked.

One significant but minor adjustment was necessary in using the NARA. The test booklet containing the three parallel forms of graded reading passages presents Form A on yellow paper, Form B on white paper, and Form C on blue paper. For the purpose of assessing reading performance in which color is being tested as a significant element of perfor-

mance, it was necessary to present all the narratives for each form of the test on white paper. This also simulated the usual reading situation of black print on white paper.

The Formal Reading Inventory (FRI), like the NARA, is intended for individual administration. The student book contains four parallel forms of the test: Forms A, B, C and D. Each form of the test consists of 13 stories and five comprehension questions for each story. Within each form, the stories have been sequenced from the easiest to most difficult according to their statistically determined difficulty relative to comprehension (Wiederholt, 1986). Students record their responses to the comprehension questions on the Student Record Forms, which also have space for the examiner to summarize the results of the tests. The performance analysis of the FRI gives a silent reading quotient and a classification of oral reading miscues made by the student. The student reads from Form A silently and reads Form B orally. Forms C and D are used in a similar manner as parallel measures for posttesting. Both Silent Reading Quotients (SRQ) and percentile ranks are provided. Because the administration of the FRI calls for the level of the oral reading passages to vary depending on the performance level the child reaches on the silent comprehension passages, the silent reading comprehension performance (Forms A and C) was used only to complement the comprehension results obtained on the NARA.

The dependent variables were reading rate, reading accuracy, and reading comprehension across the treatment groups using a Kruskal-Wallis one-way analysis of variance in an expanded Solomon Four design (Campbell & Stanley, 1963), and post hoc analyses between groups using the Steele Test (Miller, 1966).

## RESULTS

Table 1 summarizes the pretest and posttest scores for each treatment group in reading rate, reading accuracy, and reading comprehension on the Neale Analysis of Reading Ability and for reading comprehension on the Formal Reading Inventory. Table 2 summarizes the degree of change in months for each

of the groups on reading rate, reading accuracy, and reading comprehension on the NARA and reading comprehension on the FRI. Table 3 summarizes the direction of change for each of the treatment groups on the NARA for reading rate, reading accuracy, and reading comprehension.

Every child in Group A (scotopic students given the correct colored transparencies) improved in reading rate on the posttesting; 16 out of 17 improved in reading accuracy, and all 17 improved in reading comprehension. Group B (scotopic students given clear transparencies) varied in performance. On reading rate with the NARA, 5 students improved, 2 were unchanged, and 10 regressed. On reading accuracy, 4 improved, 3 were unchanged, and 10 regressed. On reading comprehension, 2 improved, 3 were unchanged, and 12 regressed. Group C (scotopic students given a colored transparency other than the preferred color) also varied in performance: On reading rate and reading accuracy, 6 improved, 3 were unchanged, and 8 regressed. On reading comprehension, 4 improved, 6 were unchanged, and 7 regressed. Similarly, the performance for Group E (nonscotopic students given clear transparencies) and Group F (nonscotopic students given a random colored sheet), varied between improvement, being unchanged, and regression. Similar results were evidenced with the FRI comprehension changes (see Table 2). Figure 1 illustrates graphically the mean change scores in months for each group in reading rate, reading accuracy, and reading comprehension on the NARA.

A Kruskal-Wallis one-way analysis of variance was used to test statistical significance of the differences among the groups on each of reading rate, reading accuracy, and reading comprehension on the NARA and for reading comprehension on the FRI. The differences among the groups were significant at the .001 level for each measure (NARA Reading Rate  $H$  value = 27; NARA Reading Accuracy  $H$  value = 21; NARA Reading Comprehension  $H$  value = 32; FRI Reading Comprehension  $H$  value = 92). Post hoc procedures were performed using the Steele Test, which indicated that the change scores of Group A were statistically significant at the .001 level for

**TABLE 2**  
Group Mean Change Scores (in Months) Between Pretesting and Posttesting for Groups A, B, C, E, and F

Group	Treatment	Neale			FRI Reading Quotient
		Rate	Accuracy	Comprehension	Comprehension
A	Scotopic	+6.6	+6.9	+19.35	+16.35
	Correct color				
B	Scotopic	-3.76	-3.18	-5.94	-5.35
	Clear transparency				
C	Scotopic	-1.7	-0.18	-0.29	+0.53
	Incorrect color				
E	Nonscotopic	-1.0	-0.18	-0.77	-1.38
	Clear transparency				
F	Nonscotopic	-2.0	+0.88	+2.58	+0.08
	Random color				

Note. FRI = Formal Reading Inventory

**TABLE 3**  
Number of Students Improving and Regressing in Reading Age (in Months) for Reading Rate, Reading Accuracy, and Reading Comprehension on the Neale Analysis of Reading Ability for Groups A, B, C, E, and F

Group	Reading rate			Reading accuracy			Reading comprehension		
	+	NC	-	+	NC	-	+	NC	-
A (n = 17)	17	0	0	16	1	0	17	0	0
B (n = 17)	5	2	10	4	3	10	2	3	12
C (n = 17)	6	3	8	6	3	8	4	6	7
E (n = 12)	3	2	7	8	0	4	4	2	6
F (n = 13)	5	2	6	5	4	4	3	5	5

Note: + = number improved; - = number regressed; NC = no change.

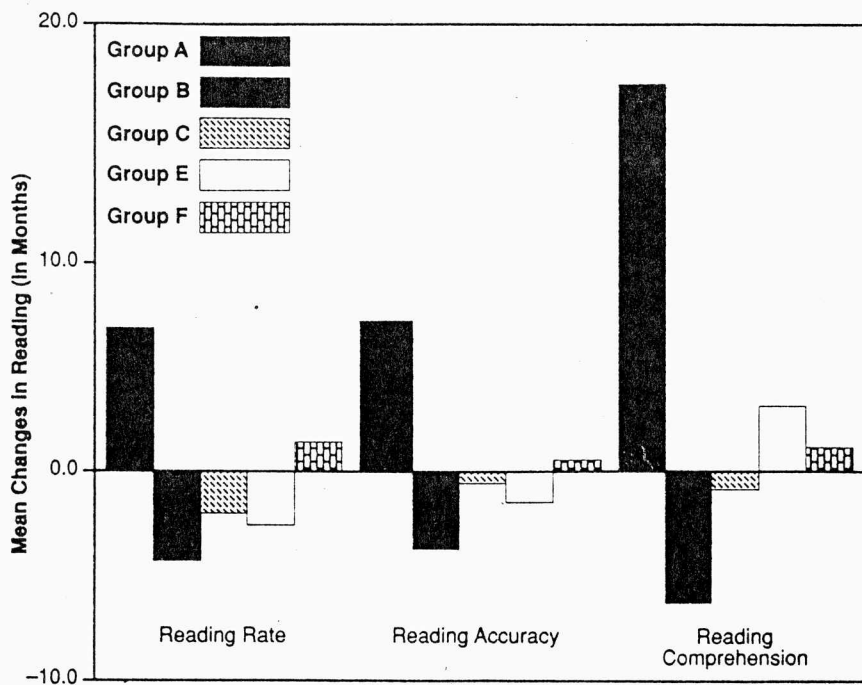


Figure 1. Mean changes in NARA reading rate, accuracy, and comprehension for each treatment.

reading rate, reading accuracy, and reading comprehension on the NARA, and reading comprehension on the FRI.

## DISCUSSION

The difference between the scotopic group that received the correct colored transparencies (Group A) and all other groups provides some support for the efficacy of the effects of colored filters on reading performance. Group A gained an average of 6.6 months in reading rate, 6.9 months in reading accuracy, and 19.35 months in reading comprehension. The only other striking change in performance among the groups was for the scotopic group given clear transparencies (i.e., Group B); they regressed 3.76 months in reading rate, 3.18 months in reading accuracy, and 5.94 months in reading comprehension. That is, for two groups that were tested for homogeneity of variance after randomization and shown to be statistically similar, 1 week later there was an average of 11 months' difference in rate, 10 months' difference in accuracy, and 35 months' difference in comprehension performance when retested under their respective conditions. It should be noted that the only difference in conditions was that Group A was posttested with their preferred colored transparencies over the white paper, while Group B, also scotopic, was posttested with clear transparencies over each reading passage on white paper. It must be stressed that all students were tested under double-blind procedures. The three independent reading assessors were not aware of the research design and were not aware which children were designated scotopic or nonscotopic.

Group C (scotopic children who were given colored transparencies *other than* the correct color) performed similarly as a group in both the pretesting and posttesting. However, there was considerable variability, with some students improving and some regressing with the assigned colored transparency. Subsequent interviews with teachers and students revealed that among this group of students several had complained that the colored filter "made it worse," while others had remarked that the colored filter made it easier to see and read. It might be hy-

pothesized that several of this group were so scotopic that they benefited from any color over white paper even when it was not the preferred color, while others actually found the assigned color made it more difficult and hurt their eyes. Similarly, post hoc reports from children in Group B indicated that the clear sheets made the glare from the white paper much worse and hurt their eyes. That is, for these scotopic students, the clear transparency overlays on white paper actually increased their reading problems. This could account for why these students actually regressed considerably in just 1 week. For the nonscopic groups (E and F), the clear and colored transparencies had no significant effect.

The results are very encouraging for continued research on the use of colored filters as a means of reducing reading disabilities within the limitations of the study. First, while all students had been screened for visual problems, some had not had a formal optometric assessment. It would have been preferable if all students had been assessed by a formal optometric or ophthalmologic examination. However, to counter this, students who demonstrated visual disorders with the perceptual tasks and who did not show any improvement with any of the color transparencies were eliminated from the sample. Second, this study used colored overlay transparencies, not individually prescribed Irlen tinted lenses. It would have been preferable to use individually prescribed Irlen tinted lenses, but this would have added considerable expense to the cost of conducting the study with such a large sample size. This would be the obvious approach for future follow-up research. However, the use of the colored overlays for this study is a very legitimate first step in researching the Irlen technique because the screening with the IDPS only uses colored overlays, and it is on the basis of this diagnosis that decisions are made whether or not to recommend prescription of an individually tinted filter as lenses. While it appears that the actual color of the prescribed Irlen tinted filter lens may not be similar to the preferred colored overlay, relief of symptoms and improvement in reading performance by a particular colored overlay appears to be better than white paper. Considering the magnitude

of the results with just a choice from among 10 colored overlay transparencies, it could be speculated that future research using actual tinted lenses, with individually prescribed tints, may lead to even more impressive changes. Certainly Robinson and Conway's study (this issue), though limited in design and sample size, suggests this would be so. Finally, it could be argued that the length of the intervention between pretesting and post-testing would be a limitation. Certainly future studies with actual lenses measuring change in reading performance over several months would be desirable. However, the degree of change in just a week is encouraging, especially as the design of the study controlled for possible argument that this is a mere placebo effect.

## CONCLUSION

The present research design controlled for the previous suggestion by some critics that the colors were mere placebos or that the improvements with the colored filters were due to motivational changes. The research was designed to control for many possible explanations, including independence of the reading assessors, testing effects, maturational factors, and placebo effects. If previous results with Irlen tinted lenses were due to mere placebo or motivational effects, why was there not improvement in the scotopic groups with the wrong colors and the nonscopic groups given overlays? Why did the scotopic group with the clear overlays (Group B) and some of the children in the group given the wrong colored transparencies regress in performance if placebo or motivational change was the explanation? While it is accepted that the changes may well be due to the interaction of several factors, the results appear to weaken the argument that the reported effects of the Irlen tinted filters are placebo or motivational in nature. The results of this study tend to suggest that the changes in reading performance, particularly reading comprehension, are due to substantive effects of the colored filters. It should be noted that the gains demonstrated by the scotopic students in Group A were obtained in 1 week with just colored overlays, not even carefully prescribed Irlen lenses. It could be hy-

pothesized that individually prescribed Irlen tinted lenses, which combine several colors in a finely tuned assessment of the filter required to eliminate all symptoms (often with different tints on each eye), might result in at least similar if not better gains in reading performance. The preferred colored transparency would only be a starting point and a crude approximation of the tint required to eliminate stress and reading disabilities, if Irlen's thesis is correct.

The present research, with double-blind procedures, provides some evidence that the Irlen tinted lens technique may be useful in the treatment and remediation of reading disabilities. It should be stressed that tinted lenses have no effect on many students with LD and others, while being assisted considerably by the tinted lenses, still have significant learning difficulties related to other developmental disabilities.

There is clearly a need for much experimental research to fully investigate the impact of color on learning disabilities. More research with actual lenses rather than colored transparencies is needed, with design controls and extensive long-term follow up. Much more work is required in basic physiological research into the effects of the white light spectrum on perceptual and learning performance. Meanwhile, Irlen's initial work appears to deserve very close attention by researchers.

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