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EMPIRICAL REPORT

The Effect of Colored Overlays on Reading Fluency in Individuals with Dyslexia

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Abstract Colored overlays, one type of tinted filter, are plastic reading sheets tinted with color and placed over text to eliminate or alleviate a wide range of reading difficulties such as low reading rate, accuracy, and comprehension. The effects of colored overlays on reading problems associated with dyslexia were investigated in this study via a multielement design. Reading fluency was assessed when participants read with and without colored overlays. Undifferentiated responding, or decreased accuracy, resulted across three participants, suggesting that colored overlays were ineffective and potentially detrimental to participants' reading abilities. As a result, empirically validated reading techniques were implemented across individuals. These findings are discussed and recommendations are made in regards to the use of research-based reading interventions.

Keywords Colored overlays · Colored filters · Dyslexia · Reading fluency · Listening-passage-preview · Modeling

Introduction

Colored filters are used in classrooms and homes to alleviate reading difficulties that are associated with learning disabilities including dyslexia. There are different forms of colored filters including lenses and overlays. Colored lenses are lenses tinted with color and worn in eyeglasses. Colored overlays are plastic reading sheets tinted with color and placed over text (Wilkins 2003). A variety of claims are made that colored overlays can help individuals who are experiencing a range of difficulties such as low reading fluency characteristic of reading problems and dyslexia (Wyman 2013), poor eye contact typical of autism, and depth perception issues caused by traumatic brain injuries ("Who We Help," n.d.).

Colored overlays are most closely linked with Scotopic Sensitivity Syndrome (SSS), also known as Meares-Irlen Syndrome or Irlen Syndrome (Loew and Watson 2012). This syndrome has been hypothesized as sensitivity to frequencies of the light spectrum that causes visual stress (Hoyt 1990). Colored overlays are claimed to alleviate visual stress and improve symptoms commonly related to dyslexia such as low reading rate, accuracy, and comprehension (Evans et al. 1999; Rickelman & Henk, 1990; "What is Irlen Syndrome," n.d.). This claim may be because visual stress often co-occurs with dyslexia (Singleton and Trotter 2005; Singleton and Henderson 2007). Colored overlays have become so common, they are now considered an approved accommodation for standardized tests in several states including California, New Mexico, Massachusetts, Nevada, and Oklahoma ("Published Research," n.d., para.1). Colored overlays are promoted by various groups and commonly referred to as the "Irlen Method" (Irlen 1991; Sawyer et al. 1994).

The theory underlying colored overlays as a treatment is that many cases of dyslexia are attributable to SSS. Individuals with a diagnosis of SSS may have difficulty fluently reading a text or may quickly become fatigued while reading. Colored filters are intended to relieve these issues and improve reading performance. However, both the existence of SSS and the usefulness of colored filters are

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controversial (Blaskey et al. 1990; Helveston 1990; Solan and Richman 1990; Williams et al. 2004; Woerz and Maples 1997). For example, Iovino et al. (1998) found that colored filters in the form of an overlay did not differentially affect the reading rate or accuracy of individuals with and without reading disabilities. Ritchie et al. (2011) also found that there was no immediate benefit of colored overlays on reading difficulties. On the contrary, (O'Connor et al. 1990) found improved reading rate and accuracy when the individual with reading difficulties read with the preferred color of overlay. Wilkins (2002) found a significant difference in the rate of reading in the group using a colored overlay compared to a control group. It should be noted that research supporting the effectiveness of colored filters in individuals with reading difficulties has been questioned due to design flaws (Handler and Fierson 2011; Ritchie et al. 2011; Solan 1990). Although the use of colored overlays is largely controversial, they continue to be commonly used by educators and parents to treat reading difficulties (Helveston 1990) and are purported to be effective in alleviating the symptoms of dyslexia (Kriss and Evans 2005).

When selecting a colored overlay to use, individuals with reading difficulties essentially choose their preferred color when given a field of overlays presented over text or are asked to read with different colors to determine which one makes a difference while reading. The procedure is typically an assessment method based on trial-and-error (Willis and Lockee 2009), but it has been shown that there is relatively little variation in color effect, so specificity in color selection does not appear critical (Wilkins et al. 2005). After the color of overlay is chosen, most researchers and practitioners deliver the intervention by simply placing the colored overlay over the text prior to reading (Ritchie et al. 2011; Scott et al. 2002). Whether this is the precise procedure prescribed by the Irlen Method is unclear as the protocols used by the Irlen Institute are proprietary and not widely known (Kruk et al. 2008). The current study followed the procedure most frequently used in research on colored overlays, and simply placed a colored overlay over text to filter the light.

In sum, colored overlays are a common but controversial intervention for individuals with a range of reading problems, including dyslexia. Some research has provided support for the intervention whereas other research has not. The purpose of this study was to add to the body of research in several ways. First, we examined the effects of colored overlays to improve reading fluency of individuals with dyslexia by comparing reading fluency with and without use of colored overlays. If no differences were found, we implemented Listening-Passage-Preview (Daly and Martens 1994; Eckert et al. 2002) or Modeling (Knapp and Winsor 1998; McCurdy et al. 1990; Skinner et al. 1997) to improve reading fluency of each participant. Second, whereas the body of research investigating colored overlays has relied on pre-post tests to determine treatment effect, we sought to directly and repeatedly measure reading fluency to determine whether the intervention had any effect across multiple measures of reading behavior. Finally, as most research on colored overlays has been conducted with children only, this study sought to extend current research by examining the effects across both children and adults.

Method

Participants, Setting, and Materials

This study included three participants who had been independently diagnosed with dyslexia and no other disabilities. Emily was 7 years old and was diagnosed by an independent psychologist. Lindsay was 11 years old and was diagnosed by the school psychologist assigned to her elementary school. Lisa was 32 years old and was diagnosed with dyslexia by a center for the study and treatment of dyslexia. Emily attended a school that specifically served children with learning disabilities. She was not currently using colored overlays, but had been prescribed them in the past. Lindsay was receiving additional services to address reading difficulties in her classroom and was currently using reading rulers (a narrow, tinted plastic strip placed over text) as a form of treatment. Lisa was not receiving reading support outside that of the study. Participants or their guardians provided consent to participate in this study.

All sessions were conducted in the homes of the participants with one exception—halfway through the study, Emily's sessions moved from her dining room to a small classroom at her school. Both settings included tables and chairs. To control for setting variables, baseline was conducted in the new setting before a Modeling intervention was implemented. For Lindsay and Lisa, all sessions were conducted in a small room with a table and chairs in the home. All Overlay and No Overlay sessions (described below) lasted 1 min. Modeling and Listening-Passage-Preview sessions (described below) lasted less than 5 min but varied in length depending on how long it took the experimenter to read the passage aloud. Approximately three sessions were conducted per week.

For Emily and Lindsay, reading passages were used from the progress monitoring probes of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), which is a standardized measure and research-based tool designed to assess essential skill areas of early literacy including accurate and fluent reading (Good and Kaminski 2002) and includes leveled reading passages across kindergarten through 6th grades. Emily read from 1st grade progress monitoring probes and Lindsay read from 5th grade progress monitoring probes based on Fuchs and Fuchs (2011) recommendation for using passages written at the student's current grade level. For Lisa, level 8.0

passages were selected from Marshal Adult Education™ which provides leveled passages appropriate for adult learners. To ensure that the level of reading was appropriate for each learner, the experimenters followed Fuchs and Fuchs recommendation on how to identify the level of material for monitoring progress for Passage Reading Fluency. Fuchs and Fuchs recommend, "If the student reads more than 50 correct words in 1 minute, move to the highest level of text where he/she reads between 10 and 50 words correct in 1 minute" (p. 11).

To increase external validity, the colored overlays used by participants were tinted plastic reading sheets by Maxi-Aids ordered from Amazon.com. This mimics the typical implementation by a parent or educator, as there are a variety of options available outside of the realm of the Irlen Institute. The set of tinted reading sheets by Maxi-Aids was the first result when "colored overlays" was entered as the search term in Amazon.com. The colors of overlays included pink, orange, yellow, red, light blue, and dark blue. Each overlay was 8.5″×11″ to cover the entire reading passage and surrounding white areas.

Measurement, Interobserver Agreement, and Procedural Fidelity

To assess the effect of treatment conditions on reading fluency for each session, the experimenter measured the number of words read correctly and incorrectly per minute as the dependent variables. In order to be scored as correct, the word must have been read within 3 s. If a participant self-corrected, stuttered, or mispronounced a word, it was scored as incorrect. An independent observer was present in order to assess interobserver agreement (IOA) and procedural fidelity. For interobserver agreement, an independent observer simultaneously scored correctly and incorrectly read words per minute. Exact count-per-session IOA was calculated by comparing both measures and determining whether the measures for each session agreed. The total number of agreements was then divided by the number of agreements plus disagreements and multiplied by 100. IOA was calculated across 88.8 % of all sessions for Emily, 100 % of all sessions for Lindsay, and 94.7 % of all sessions for Lisa. Interobserver agreement was measured at 99.6 % for Emily, 99.6 % for Lindsay, and 99.8 % for Lisa.

To assess procedural fidelity, the experimenter created a checklist of the procedures for each condition including Overlay, No Overlay, Listening-Passage-Preview, and Modeling (explained below). The specific steps of each condition were listed, and the independent observer recorded whether or not the step was implemented by the experimenter. The total number of YES scores recorded for each session was then divided by the number of steps answered either YES or NO for each checklist and multiplied by 100 to produce a measure of procedural fidelity for each session. The procedural fidelity measures for all sessions were then totaled and divided by the number of sessions assessed to determine overall procedural fidelity for each participant. Procedural fidelity across all sessions was measured at 100 % across all participants.

Procedures and Experimental Design

Assessment All procedures were conducted by the first author. A Multiple Stimulus without Replacement preference assessment (DeLeon and Iwata 1996) was conducted with each individual to determine the preferred color of overlay. This was done to both allow participants multiple exposures to each color as well as more objectively determine preference. Six colored overlays were each presented over identical pages of text. The participant was asked "Which one is the clearest" and indicated by pointing. The chosen color of overlay was removed from the array, the order of the remaining overlays was rearranged, and the next trial began with a reduced number of overlays in the array. The procedure was repeated three times for each participant before reading sessions began. The participant's preferred choice for colored overlay was identified by calculating the percentage of trials each overlay was selected by dividing the number of times it was included in the array by the number of times it was selected. If the color of overlay was ranked as the highest preference in at least two out of the three administrations, then it was identified as the preferred overlay. Once experimental conditions began, this assessment was not repeated and each participant read with the identified preferred color of overlay for all Overlay conditions. Emily's preferred color of overlay was dark blue, Lindsay's preferred color of overlay was yellow, and Lisa's preferred color of overlay was light blue.

Intervention Conditions Initially, each participant was exposed to two conditions: reading a DIBELS passage with the preferred colored overlay (Overlay) and reading a DIBELS passage with no colored overlay (No Overlay). Each session lasted 1 min. Although colored overlays are often used for durations longer than 1 min, previous research has shown that this duration is long enough to demonstrate the effects of colored overlays (Wilkins et al. 1996). In the Overlay condition, the colored overlay was simply placed over the reading text prior to a request to read. This was the predominant procedure used in research on colored overlays (e.g., Ritchie et al. 2011). All of the standardized procedures of the DIBELS were followed for both conditions. The reading passage was placed in front of the participant. The participant was instructed to read aloud and continue until the experimenter said "stop." On a separate but identical text, and outside of the view of the participant, the experimenter placed a slash mark over any words read incorrectly. At the end of the 1 min reading duration, the experimenter said "stop," placed a

bracket after the last word read by the student, and terminated the session. The only exception to the DIBELS procedures was in the Overlay condition, wherein the DIBELS passage was presented with the colored overlay over the text. The effects of the colored overlay were assessed via a multielement design.

In addition, Listening-Passage-Preview, followed by Modeling, was implemented as treatment for Emily, and Modeling was implemented as a treatment for both Lindsay and Lisa. Listening-Passage-Preview (LPP) is considered to be an effective intervention for increasing reading fluency and accuracy (Daly and Martens 1994; Eckert et al. 2002). In the LPP condition, the participant was handed the DIBELS passage (without a colored overlay) and instructed to visually follow along while the experimenter read the passage aloud. The participant was then instructed to read the passage while the experimenter marked correct words read and errors. If an error was made, the experimenter immediately provided corrective feedback by interrupting the participant, stating the correct word, and having the participant restate the word before continuing with the passage. Finally, the participant read the passage a second time without corrective feedback for 1 min and the experimenter assessed correctly and incorrectly read words per minute.

Modeling is also considered to be an effective intervention for increasing reading fluency (Knapp and Winsor 1998; McCurdy et al. 1990; Skinner et al. 1997). Modeling was implemented by having the participant follow along in the reading passage by tracking the text with a finger as the experimenter read the passage aloud. Next, the participant read the passage for 1 min and the experimenter assessed correctly and incorrectly read words per minute. Each administration of either the LPP or Modeling treatment constituted a session respectively. Following procedures outlined by Daly and Martens (1994), reading fluency was measured as the final step of treatment within each session and constituted the assessment of oral reading fluency. Different DIBELS and Marshal Adult Education passages were used for each reading session.

Results

Figure 1 demonstrates Emily's correct words per minute (CWPM) and errors per minute (EPM). During the initial comparison between Overlay and No Overlay, Emily read an average of 49 CWPM in the No Overlay condition and 48 CWPM in the Overlay condition. There was a slight but steady decreasing trend in CWPM across both conditions. In addition, Emily had an average of 3 EPM across both No Overlay and Overlay conditions, with an increase in EPM during the final sessions. There was a decreasing trend in CWPM and a low to moderate level of errors across sessions for both conditions.

During the Listening-Passage-Preview (LPP) phase of the study, Emily's level of correct and incorrect responding remained somewhat similar to that of the No Overlay and Overlay conditions (an average of 49 CWPM and 1 EPM) across sessions, although it does appear as though the decreasing trend in CWPM ceased, and errors were lower than during either No Overlay or Overlay conditions. Approximately 1 month had passed between the end of the LPP condition and the next phase of the study. During this time, Emily attended a reading camp and circumstances required a change in the environment where sessions were held. As a result of the passage of time and the possibility of history and/or multiple treatment effects, there was a return to the No Overlay condition prior to moving to the Modeling phase. During the return to No Overlay, Emily read an average of 43 CWPM (with a slight decreasing trend) and 3 EPM across sessions. Following this return to No Overlay, the Modeling intervention was implemented. During this condition, Emily reads an average of 64 CWPM. There was a steep increasing trend in CWPM and errors were at a relatively low rate (an average of 1.3 EPM).

Lindsay's CWPM and EPM are displayed in Fig. 2. During the initial comparisons, Lindsay read an average of 70 CWPM across No Overlay sessions and 62 CWPM across Overlay sessions. In addition, Lindsay had a low level of errors in the No Overlay and the Overlay sessions (an average of 1.5 and 2 EPM, respectively). There was a slight increasing trend in CWPM in the No Overlay condition. When the Modeling phase was implemented, the increasing trend in CWPM continued, though at what appears to be a somewhat increased slope. During this phase, Lindsay reads an average of 88.4 CWPM with a low level of errors (an average of 1.4 EPM).

Figure 3 demonstrates Lisa's CWPM and EPM. Lisa reads an average of 90.4 CWPM across No Overlay sessions and 73.6 CWPM across Overlay sessions. There appears to be a decreasing trend in CWPM across both conditions. Lisa averaged a similar and moderate level of EPM across No Overlay and Overlay sessions (an average of 4.4 EPM). Upon implementation of the modeling intervention, there was an immediate increase in CWPM and decrease in EPM. Lisa reads an average of 103 CWPM accompanied by a low level of errors (an average of 1.8 EPM).

Discussion

Despite the research suggesting colored overlays is not an effective treatment for dyslexia, colored overlays continue to be used as an intervention to improve reading skills of individuals with dyslexia. The authors of this study sought to add to the literature regarding the effect of colored overlays on reading fluency for individuals with dyslexia, as well as

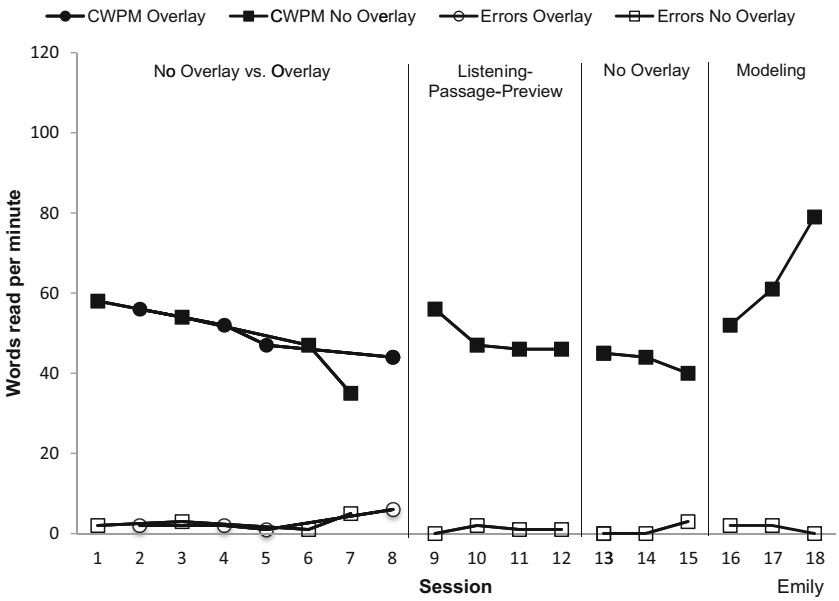

Fig. 1 Correctly and incorrectly read words per minute for Emily

extend the literature by investigating the effectiveness across age levels, ranging from 7 to 32 years old. When colored overlays were ineffective, the authors then investigated the effects of research-based reading interventions on oral reading fluency for the same individuals. The results of this study indicate that colored overlays either had no effect on words read correctly per minute (as was the case for Emily and Lindsay) or resulted in a decrease in words read correctly per minute (as was the case for Lisa). These results support the previous research demonstrating colored overlays have little effect on reading fluency (e.g., Ritchie et al. 2011). Further, whereas previous research has suggested that colored overlays have greater effect on children with dyslexia than adults (Singleton and Trotter 2005; Singleton and Henderson 2007), this study suggests that colored overlays may have a deleterious effect on adults. Although colored overlays did not improve reading fluency for the children in this study, the adult's performance actually worsened with the colored overlay intervention.

As a final phase of this study, research-based interventions (Listening-Passage-Preview and Modeling) were implemented across participants to investigate their effects on reading fluency. Although the effects of these interventions were somewhat minimal (with the exception of the Modeling intervention for Emily which produced a sharp increasing trend), the LPP and Modeling interventions resulted in superior CWPM than either the No Overlay or Overlay interventions.

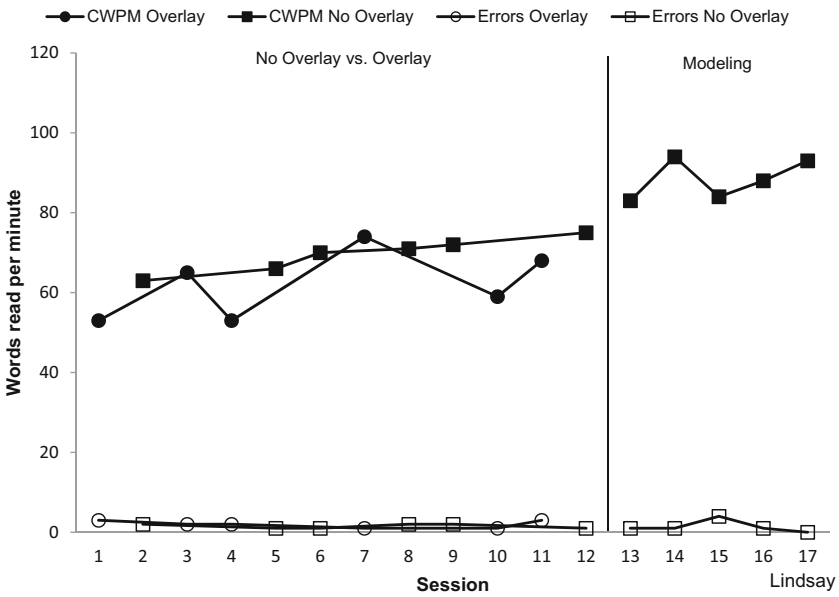

Fig. 2 Correctly and incorrectly read words per minute for Lindsay

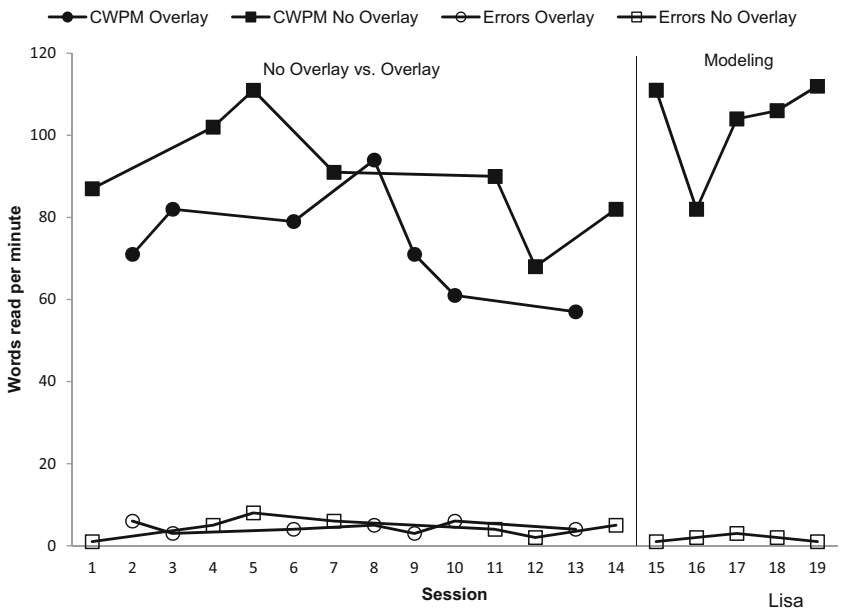

Fig. 3 Correctly and incorrectly read words per minute for Lisa

Limitations and Future Research

One limitation of this study is that the effects of the Modeling intervention cannot be experimentally validated. As a result, it is difficult to attribute gains in CWPM to the Modeling intervention alone. Although Modeling as an intervention has been experimentally validated elsewhere (e.g., Knapp and Winsor 1998; McCurdy et al. 1990; Skinner et al. 1997), when attempting to compare the effects of one intervention to another, the comparison needs to be conducted in such a manner that effects can be directly linked to one intervention or the other. However, the effects of the colored overlay may be experimentally compared to no colored overlay.

A second limitation is that the participants were never directly assessed for Scotopic Sensitivity Syndrome. All participants had an independent diagnosis of dyslexia, and two of the participants had previously been prescribed colored overlays or colored overlay variations (e.g., a tinted reading ruler). Further, colored overlays are commonly used with individuals with dyslexia or without a diagnosis of SSS (Henderson et al. 2013; Scott et al. 2002), and the status of SSS as an actual syndrome has been questioned (Ritchie et al. 2011). As no participants were assessed for SSS, the generality of these results may be limited to the population of individuals with dyslexia. Future research should assess participants for SSS prior to inclusion in a study on colored overlays which would allow the researcher to focus on the relation between colored overlays and SSS more clearly.

Although colored overlays did not increase CWPM in any of the individuals, two of the participants reported a preference for reading with the colored overlay. Not only did Emily and Lindsay prefer using the colored overlay, they both anecdotally reported that the colored overlay helped them read better. Lisa reported that she did not prefer using the colored overlay. This finding may be related to each participant's previous exposure to tinted overlay interventions as both Emily and Lindsay had previous exposure while Lisa did not. Even though two participants reported a preference for reading with an overlay, the intervention did not increase reading fluency for either individual. This preference, however, should not be discounted. If a participant with reading difficulties prefers to read with a colored overlay, the overlay might increase motivation to read which could prove beneficial. Future research may investigate whether colored overlays improve reading abilities over time through this mechanism, rather than through a direct effect on visual stress. In addition, the authors considered implementing a clear, non-colored overlay as a control condition to investigate potential placebo effects of the overlay. Because the clear, non-colored overlay would not be included in the same pack of purchased overlays, it was decided to implement this condition only if an improvement in reading fluency was observed in the Overlay condition. Future research might consider the investigation of a clear, non-colored overlay as a control condition.

Colored overlays continue to be commonly used in homes and classrooms as interventions for reading problems. Based on the mixed literature regarding the use of this treatment, parents and educators should exert caution when deciding whether to adopt colored overlays, and the effects on reading fluency should be evaluated carefully on an individualized level. In other words, parents and professionals who choose to adopt overlays as a reading intervention should consider similar methods to evaluate whether or not it is an effective use of time and effort. The data from this study suggest that colored overlays do not improve performance on reading, but other evidence-based treatments do. It is also important to note

that preference for an intervention, such as colored overlays, is not indicative of effectiveness.

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