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E-readers as an alternative to coloured overlays for developmental dyslexia in adolescents

This explorative study investigated whether there was a difference in reading speed and errors made when reading using a coloured overlay and reading using an e-reader for adolescents with developmental dyslexia. A clinical sample of adolescents (N = 17) aged 11-16 were used. It was found that there were only very small (non-significant) differences in the mean reading speeds and reading errors when reading using either a coloured overlay of any colour or on an e-reader. This suggests that coloured overlays and e-readers are equally effective interventions for developmental dyslexia. The application of e-readers in an educational setting is discussed.

Introduction

Dyslexia translates to ‘bad’ (*dys*) ‘reading’ (*lexia*) and affects 3-6% of children (Wickens, 2005). Interventions to aid symptoms of dyslexia include the use of coloured overlays during reading (Kriss & Evans, 2005) in order to reduce the effects of contrast sensitivity. Contrast sensitivity is difficulty perceiving colours when they are presented on a background which is a highly contrasting colour.

Laycock et al (2011) used an abrupt and alternate (ramped) flicker defined methodology in order to measure contrast sensitivity threshold using high temporal frequency contrast reversals. A sample size of 17 participants, aged 9-14 years, with developmental dyslexia were found to have increased contrast sensitivity (such as black text on white paper) thresholds (Laycock et al, 2011) compared to chronological age control participants (N=44). Visual deficits have led to direct similarities being made between the magnocellular theory of

developmental dyslexia and Meares-Irlen Syndrome (Boyle & Jindal-Snape, 2012). Meares-Irlen Syndrome is characterised by distortions in visual perception and visual stress (Kriss & Evans, 2005). Both visual stress and visual perception distortions can be alleviated, in some individuals, by using coloured filters, known as overlays (Kriss & Evans, 2005; Evans, 2001). Coloured overlays are sheets of transparent plastic (Kriss & Evans, 2005) that can, in some individuals, neutralise contrast sensitivity between the black text and white background that the text is printed on. Coloured overlays are individually prescribed (Evans, 2001) as they are available in a plethora of colours (Kriss & Evans, 2005). The different coloured overlays reflect differing wavelengths of light (Wilkins, Lewis, Smith & Rowland, 2001). This relates to the wavelengths to which magnocells and parvocells (which are part of the lateral geniculate nucleus) respond. (Wickens, 2005). Coloured overlays are also used as an intervention for visual deficits found in developmental dyslexia (Wilkins, 2003).

Wilkins et al (2001) compared perception and reading speed of black text on white paper to black text read using a coloured overlay. Participants aged 6-8 years old were recruited from 12 schools, with an average number of 35.5 children participating from each school. Fifty-two percent of participants were found to have improved their perception of the text by using a coloured overlay. Reading speed also increased in individual participants, suggesting that contrast sensitivity was lowered and participants were able to decipher the text more easily.

Kriss and Evans (2005) compared the effectiveness of coloured overlays with dyslexic adolescents and a control group. The control group consisted of age matched participants (7-12 years of age) who could all read 15 words on the Wilkins Rate of Reading Test (WRRT; Wilkins, Jeanes, Pumfrey & Laskier, 1996), however the defining difference between the groups was that the dyslexic group had been diagnosed by an educational psychologist. The WRRT was used for reading material in this study. Overall reading speed and the number of errors made were recorded in order to compare the use of an overlay with no overlay. A

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significant improvement was found in reading speed for the dyslexic group but not for the control group when using the overlay. This suggests that coloured overlays are beneficial for neutralising contrast sensitivity in developmental dyslexia. Furthermore, a grey overlay was the second most popular choice by dyslexic participants.

An e-book (electronic book) is commonly known as an e-reader (Shwu-Ching, Young & Lin, 2012). E-readers are lower in colour contrast than printed paper (Siegenthaler, Wurtz, Bergemin and Groner, 2011) as they use black ink on a grey background. Gould, Alfaro, Barnes, Finn and Grischkowsky (1987) studied non-dyslexic participants and found that reading speed was slower when using an e-reader because more time was spent on fixation. They proposed that reading speed is calculated by multiplying mean fixation duration by the number of eye fixations (Gould *et al.*, 1987). It was suggested that in this instance greater fixations were due to differences in image quality between the two reading mediums (Gould *et al.*, 1987). Siegenthaler *et al.* (2011) investigated reading behaviour by comparing reading on different mediums although again; with non-dyslexic participants. Reading print on paper was compared to reading on an e-reader. Overall, regressive - backwards - saccades when reading were similar when using an e-reader or print on paper. However, although fixations (where there are no eye movements) were different between the two mediums with fewer fixations during paper reading, it was suggested that this meant that e-readers may provide better legibility when reading than paper (Siegenthaler *et al.*, 2011). This suggests that longer fixations correlate with increased print processing time, which correlates to reduced legibility. The suggestion that e-readers may provide as much legibility, if not more so, than paper indicates that it may be easier to read using an e-reader than reading words on paper. As a result it is possible that when reading using an e-reader reading speed may increase and there may be fewer reading errors.

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The current study aimed to investigate whether e-readers are as effective at neutralising contrast sensitivity as coloured overlays (Wilkins et al, 2001; Kriss & Evans, 2005) when reading. The current study focused specifically on adolescents (aged 11-16) with developmental dyslexia. The current study proposed that there would be no differences in reading speed and errors made when reading using a coloured overlay or on an e-reader.

Method

Participants: Seventeen participants aged 11-16; 12 were males and 5 were females, were recruited from a secondary school in Yorkshire. All participants were students that had been previously assessed for developmental dyslexia by the school using a dyslexia screener provided by Crossbow Education (<http://crossboweducation.com>). If participants wore glasses for corrective vision they were told to wear them as normal when reading. All participants had been previously found to show improvement in the symptoms of their dyslexia when using a coloured overlay. One participant used coloured lenses as opposed to a coloured overlay and so wore them as an alternative to the overlay.

Design: A cross-sectional, quasi experimental, between groups design was adopted. The Independent Variable (IV¹), named reading method, had two levels; the coloured overlay and e-reader. As participants had been previously screened for an appropriate coloured overlay, the recommended coloured overlay was used as a comparison to the e-reader and could be viewed as a control. The first DV (DV¹) was reading speed. This was recorded in minutes and seconds. Time taken when swiping the page on the e-reader was compensated for by time taken turning the page of the book. The second DV (DV²) was the number of errors made while reading. If the same word was continuously misread it was only recorded as one error. It was ensured that each participant read the same amount of text on each reading medium;

for example if after 15 minutes a participant only read 3 pages using their overlay then they wouldn't be allowed to read more than 3 pages using the e-reader. Reading speed and errors for both methods were analysed using means and standard deviations, followed by a series of one-way within samples repeated measures ANOVAs with a focus primarily on differences in reading speed as this was the focus in previous research (Wilkins et al., 2001; Kriss & Evans, 2005).

Materials: A Kobo Mini (www.kobo.com) e-reader displaying Harry Potter and the Philosopher's Stone (Rowling, 1997) and a hard copy of the text were provided for participants to read. The Kobo Mini was set to a grey background for all participants. New, untarnished, coloured overlays were also provided in case the participant hadn't remembered their own. A note of their usual overlay was provided in case participants couldn't remember which shade they normally used, as many shades of the same colour are available.

Procedure: Firstly, the first five pages of Harry Potter and the Philosopher's Stone (Rowling, 1997) were read using a hard copy of the text. The participant's individual coloured overlay was placed over the text and once they were ready, were instructed to start reading out loud. During this time reading speed was timed and any reading errors were noted discretely in order to prevent distraction or concern from the participant. Whilst the participant was reading, the researcher followed the text that was being read using the e-reader. Therefore if the participant lost their place, the researcher could point it out to them and so reading could be resumed promptly. Order effects were considered as the order the reading methods (e-reader and overlay) were presented to the participants were randomised and counterbalanced. Once five pages of text had been read, the participant was instructed to stop and take a short break. The next five pages of text were then read, following the same procedure, but this time using the Kobo Mini. A demonstration of how to use the kobo mini was given if participants were unfamiliar with using it. When reading was being carried out on the e-reader, the

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researcher followed the text by reading from the hard copy of the text. If the total reading using either method exceeded 15 minutes, reading was terminated in order to prevent participant frustration or anxiety. This early termination policy was adopted for three participants. When early termination occurred, only the same amount of text was allowed to be read using the alternative method in order to keep the amount of text being read using both devices equal. Participants were encouraged to ask any questions at various points throughout the procedure.

Results

The current study proposed that there would be no significant difference in reading speed and errors made when reading using a coloured overlay or on an e-reader. A series of means and standard deviations were calculated in order to investigate whether there was a significant difference between reading speed and reading errors when reading on an e-reader and reading using a coloured overlay. The results for means and standard deviations can be seen in table 1.

Descriptive Statistics				
	Reading Method	Mean	Std. Deviation	N
Speed	Overlays	4.8241	1.82844	17
	E-reader	5.1812	2.17524	17
Errors	Overlay	6.2941	5.31231	17
	E-reader	7.7059	6.89896	17

Table 1. Means and standard deviations for reading speed and number of reading errors when reading on an e-reader and using a coloured overlay.

Table 1 shows a small difference in the total mean regarding reading speed when reading with coloured overlays (4.82, SD: 1.82) compared to reading on an e-reader (5.18, SD: 2.18). The mean difference in reading speed across the two reading methods was 36 seconds; moreover the standard deviations suggest a small spread in reading speed scores. This suggests that any difference in reading speed is unlikely to be significant. This suggests that

whether participants read with a coloured overlay or on an e-reader reading speed wasn't affected. With regards to reading errors, table 1 shows that the difference in total mean was around 1 reading error as the mean errors when reading with coloured overlays was 6.29 (SD: 5.31) compared to 7.71 when reading on an e-reader (SD: 6.90); the standard deviations also suggest a small spread in reading errors. As a result any difference in the number of reading errors across the two reading mediums is unlikely to be significant. This suggests that whether participants read with a coloured overlay or on an e-reader neither reading speed nor reading errors were affected.

A series of one-way within samples repeated measures ANOVAs were conducted, one to investigate differences in reading speed across the two reading methods and one to investigate differences in the number of reading errors made. With regards to reading speed it was found that there was not a significant difference in reading speed between the two reading methods, $F(1, 16) = 2.964, p 0.104$, partial $\eta = 0.156$. With regards to reading errors it was found that there was not a significant difference in reading errors between the two reading methods, $F(1, 16) = 1.434, p 0.249$, partial $\eta = 0.082$. The results suggest that whether developmentally dyslexic individuals who use a coloured overlay read using a coloured overlay or on an e-reader their reading speed and number of errors made is not significantly different.

Discussion

The current research aimed to explore alternative and contemporary interventions for developmental dyslexia by incorporating research into coloured overlays with research into reading using an e-reader. It was hypothesised that there would be no difference in reading speed and errors made when reading using a coloured overlay or on an e-reader. In relation to this hypothesis, only a small difference was found between reading speed or reading errors when reading on either an e-reader or using a coloured overlay and so the likelihood of a significant difference is low. This suggests that the e-reader is as equally effective at

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neutralising contrast sensitivity as a coloured overlay. The ability of coloured overlays to neutralise contrast sensitivity (Wilkins, 2003) and increase reading capability (Kriss & Evans, 2005) is highlighted by similar effects using an e-reader. Previous research into interventions for developmental dyslexia has included, amongst other interventions, the effectiveness of coloured overlays when reading (Wilkins, 2003; Kriss & Evans, 2005) and how this compares to reading without a coloured overlay. Separate research has compared reading books and reading on an e-reader (Siegenthaler et al, 2011). The current generation of e-readers have been found to provide a reading experience that is on par with a book with regards to reading legibility (Siegenthaler et al, 2011). This is logical as black ink on a grey background naturally reduces the contrast between black and white; the primary result of a magnocellular deficit (Carlson, 2001). The application of natural contrast sensitivity neutralisation doesn't appear to have been applied to developmental dyslexia until now. Moreover, when considering that the coloured overlays used spanned a variety of colours and yet the e-reader only used grey background, the need for such a plethora of different coloured overlays is brought into question. The current research demonstrates that the use of a grey background is almost as effective for neutralising contrast sensitivity reading in developmental dyslexia as any other colour. This implies that grey could be used as a background colour for all documents in schools for students with developmental dyslexia, as opposed to supplying a plethora of different coloured resources. The amount of money spent by schools on different coloured overlays, exercise books and paper is extreme and so by reducing the different colours used in resources, costs could be decreased overall, although there is the cost of buying e-readers and replacing them every few years. The current research suggests that money could be saved by adopting the use of a standard grey overlay, paper or e-reader for books and PDFs. Adopting the use of one standard background colour would also allow teachers to be able to dedicate more time to learning and less time would be spent

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on preparing and distributing documents on different coloured paper. However, it is acknowledged that the texts that are required would have to be available digitally, to present them on an e-reader.

With regards to limitations it should be noted that the participants, apart from one, had only been screened for developmental dyslexia and did not have an official diagnosis of developmental dyslexia. The remaining participant had received an official diagnosis of dyslexia. A screener for developmental dyslexia is not the same as a diagnosis. A screener only determines the likelihood of whether an individual has developmental dyslexia (Crossbow Education) and whether a coloured overlay would be beneficial; whereas a diagnosis confirms it. However, the screener used prior to the current study is endorsed by the British Dyslexia Association (Crossbow Education) and so is robust in terms of reliability.

Future research should investigate the use of e-readers as an intervention for developmental dyslexia using a larger clinical sample of participants who have received an official diagnosis of developmental dyslexia. Moreover, the inclusion of a larger sample size would allow for a more sophisticated statistical analysis to be applied and for better power within the analysis to be achieved as this study only included 17 participants. Prior familiarization time with the e-reader may also have been beneficial, especially if participants were not familiar with e-reader or if some participants had more familiarity than others.

The current study has been exploratory as it is likely to be the first to apply e-reader research to developmental dyslexia. Findings from the current study demonstrate that there is little difference in effectiveness of e-readers, compared to the use of coloured overlays, for individuals with developmental dyslexia. It should be noted that prior exposure to the chosen text was not recorded, although it is acknowledged that given the repeated measures design

employed in this study, any effect this may have had on the findings is likely to have been small.

In conclusion, the current study has highlighted the need for further research regarding reading interventions for adolescents with developmental dyslexia. The use of e-readers as a reading method has been found to be as equally effective as coloured overlays when reading. Future research should extend the work of this exploratory study by further investigating not only the biological and neurological aspects of reading and dyslexia, but also the social implications of disabilities, such as developmental dyslexia, on adolescence.

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