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The effect of a font intervention for 4th and 5th graders with dyslexia

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The Effect of a Font Intervention for 4th and 5th Graders with Dyslexia

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Abstract

Dyslexie is a font developed by Christian Boer specifically to enhance reading fluency in students with dyslexia. The present study examined its potential impact on the performance of 36 4th and 5th grade students with SLD on story reading. We found that Dyslexie, when compared to other common fonts that have been adjusted to control for Dyslexie's large size and spacing, appears to have no effect on readers' ability to read text correctly, comprehend text, or read faster.

The Effect of a Font Intervention for 4th and 5th Graders with Dyslexia

For years, special educators and school psychologists have been searching for viable interventions for students identified with reading disabilities, which are generally referred to in the literature as dyslexia (Elkund, Torppa, Aro, Lappanen, & Lyytinen, 2014; Fernandez, Vale, Martinez, Morais, & Kolinsky, 2014; Gross-Glenn et al, 1995; Henry, 2007; Holden, Grejin, van Roojj, Wijnants, & Bosman, 2014; Jones, Branigan, Parra, & Logie, 2013; Kast, Baschera, Gross, Jancke, & Meyer, 2011; Lallier, Donnadieu, & Valdois, 2013; Livingstone, Rosen, Drislane, & Galaburda, 1991). Some of these interventions can be expensive, time consuming, or impractical (Kast et al, 2011), while some work well only with children with very specific reading issues (Friedmann & Rahamim, 2014). There has been some evidence that altering the font type of a text that children with dyslexia read can improve their reading accuracy (Bernard, Chaparro, Mills, & Halcomb, 2003; Pijpker, 2013). Altering the typeface of reading materials for children with dyslexia is a simple and inexpensive alternative to the interventions mentioned above. The current study seeks to evaluate the effect of alternative fonts on the reading accuracy of upper elementary school children identified with specific learning disabilities.

Recent History of Dyslexia

By 1975, a need in the reading literature was identified for a differentiation between children who read below expectations despite having average intelligence and children who read poorly due to low intelligence or educational deprivation. Originally, this phenomenon was referred to as specific reading retardation (Holden, Grejin, van Rooij, Wijnants, & Bosman, 2014). Today, we know it as developmental dyslexia.

Developmental dyslexia is a type of specific learning disorder. It is of neurodevelopmental origin and characterized by difficulties with fluent and/or accurate word recognition, poor spelling, and poor decoding abilities. These symptoms must be in the absence of low intelligence, lack of accessibility to adequate education, and impairments to the senses (Eklund et al, 2014; Holden, Grejin, van Rooij, Wijnants, & Bosman, 2014; Lallier, Donnadieu, & Valdois, 2013; Nielsen & Hynd, 2000; Pennington et al 2012). Developmental dyslexia differs from acquired dyslexia in that acquired dyslexia is typically caused by a traumatic brain injury or other injury to the head. Acquired dyslexia frequently occurs in adults and generally affects Broca's area in the brain. According to Holden et al (2014), the prevalence of school aged children with developmental dyslexia ranges from 6% - 17%. Further, developmental dyslexia is believed to have a genetic influence, since between 34% and 66% of children with family histories of dyslexia have reading and spelling problems themselves (Eklund et al 2014; Holden et al 2014).

Although the diagnosis of developmental dyslexia may be simple, there is individual variation in reading achievement. Eklund et al. (2014) conducted a longitudinal study in which dyslexic and non-dyslexic children were followed from grades 2 through 8. They were assessed for dyslexia and their family members were surveyed to see if familial risk factors for dyslexia were present. These children were then tested each year for reading comprehension, spelling, and writing. Children who had familial risk factors but no dyslexia scored lower on all reading tasks than children with no risk factors and no dyslexia. The authors also found that children with dyslexia acquired reading at the same rate as children without dyslexia. Further, dyslexic children are likely to have difficulty with temporal processing, balance and motor control, auditory and tactile processing, and mental calculations (Guo, Sun, Breit-Smith, Morrison, & Connor, 2014). So, while children with dyslexia develop at the same rate as children without dyslexia, they start at a lower level than their non-dyslexic peers. The authors found that this gap was never closed between grades 2 through 8. Students who fall behind in school are more likely to become bored, avoidant of academic material, have negative behavioral outcomes, and have difficulty with self-regulation (Eklund et al 2014; Guo et al 2014).

In the connectionist model of reading (Byrnes, 2008), there are four theorized ‘processors,’ each with its own responsibilities as well as capability to communicate with other processors in order to discern the meaning of a text:

- The *phonological processor* has to do with knowing the sounds that accompany written and spoken language.
- The *orthographical processor* has to do with knowing the written language.
- The *meaning processor* contains the lexicon, or mental dictionary, that finds meanings for individual words or phrases.
- The *context processor* may only communicate with the meaning processor. The context processor attempts to discern the background information from the text in which the words are placed to interpret its effect on the meaning of the text.

The phonological, orthographical, and meaning processors are able to communicate with each other. This model has some important implications for dyslexia. There are several theories behind the cause of dyslexia, and the first two rely heavily on the connectionist model.

Causes of Dyslexia

There are several different theories that are used to explain the cause of dyslexia. The four most common explanations include attentional causes, magnocellular deficits, phonological deficits, orthographical deficits, and mixed causes.

Attentional causes. The first, albeit not widely accepted, theory behind developmental dyslexia proposes that dyslexia is due to an attentional deficit. The first piece of evidence for this is that dyslexia is often comorbid with attention-deficit hyperactivity disorder (ADHD) (Holden et al, 2014). The next piece of evidence stems from the fact that the phoneme-grapheme associations required for skilled reading have high attentional loads, especially during the learning-to-read years (Jones, Branigan, Parra, & Logie, 2013). Lallier, Donnadeiu, and Valdois (2013) proposed that children with dyslexia have a condition called sluggish attentional shifting, which gives them a longer than average ‘attentional dwell’ time. This increased attentional dwell time can leave them unable to shift fast enough from one stimulus to the next in the sequence, which changes their perception of the sequence of stimuli. Lallier, Donnadeiu, and Valdois (2013) conducted a study in which they had dyslexic and non-dyslexic children perform a dichotic listening task. In this dichotic listening task, the children were given headphones that played one three-syllable pseudoword in one ear, and a different three-syllable pseudoword in the other. The children were asked to report the pseudoword that was played in one ear and the other. Children with dyslexia generally did worse than children without dyslexia, but not all children with dyslexia did poorly. This result can possibly be attributed to the degree of phonological processing and working memory required. From this study, it appears that there is a relationship between attentional deficits and reading ability, but attentional difficulties alone are not sufficient to diagnose dyslexia.

Magnocellular deficits. The next theory comes from a neuropsychological approach, and is referred to as the Magnocellular deficit theory. Stein and Walsh (1997) proposed that dyslexia can be caused by a deficit in an area of the brain referred to as the magnocellular lateral geniculate nucleus (mLGN). A study done by Schiller, Logothetis, and Eliot (1990) examined the mLGN and its function in monkeys by lesioning the mLGN and comparing the subjects to non-lesioned controls. They found that when lesioned, the monkeys had significantly reduced ability to discriminate color, form, size, texture, and disparity. Livingstone, Rosen, Drislane, and Galaburda (1991) examined the brains of five post-mortem dyslexics. He found that the dyslexic brains had mLGN areas that were 20% smaller than that of the control brains. Stein and Walsh (1997) argued that the mLGN is known to aid in the regulation of eye movement, which may account for reports from dyslexics of letters and words moving about the page. They also contended that while mLGN deficits tended to be small, they manifest as reading difficulty because mLGN deficits magnify themselves in the posterior parietal cortex (PPC), where much of the processing of information from the magnocells is conducted. This is because the PPC is sensitive to the direction of movement and gaze, but is insensitive to color and form (Galletti, Battaglini, & Fattori, 1991; Matter & Mountcastle, 1981). Further, damage to the PPC is known to cause acquired reading disorders (Kinsbourne & Warrington, 1961). Stein and Walsh (1997) point to several studies that did not find evidence for the Magnocellular theory (Gross-Glenn, 1995; Victor, 1993; Walther-Muller, 1995), and pointed out a common flaw with each of the three studies. Stein and Walsh (1997) contended that the studies failed to find magnocellular deficits in dyslexics because they mistakenly view mGLN issues as all or none, and do not take into account the heterogeneity of reading disabilities. They argue that no theory can account for all cases of dyslexia, and the Magnocellular Theory accounts for some cases.

Phonological processing deficits. The third of these theories states that dyslexia is caused by a deficit in phonological processing. This phonological deficit is specifically related to the ability to form grapheme (written letter) to phoneme (spoken sound) associations (Jones, Branigan, Parra, & Logie, 2013). This ability, called phonological coding, can manifest itself as an 'inner voice' that many skilled readers possess. While this 'inner voice' is not absolutely necessary for reading, interfering with it has been found to disrupt skilled reading (Leinenger, 2014). Leinenger (2014) further proposed three possible schools of thought regarding phonological coding during reading. The first posits that phonological codes are generated early in the reading of a text and are involved heavily in lexical access, or meaning retrieval. This school further proposes that the initial phonology of a word or phrase allows the lexicon to create a list of potential words, which is then reduced to a shorter list and, if successful, the correct word or meaning after using orthographical matching. The second school of thought proposes that phonological codes occur after lexical access, or meaning retrieval, in order to boost the short-term memory and to aid in comprehension. The grapheme-phoneme association boosts short-term memory by allowing more information to be associated with the grapheme. The third school of thought proposes that phonological coding is simply a byproduct of the way that children are taught to read – that is, by sounding out words. This has been shown to likely not be the case, because as mentioned previously, interrupting the inner voice in a skilled reader disrupts their ability to read in a skilled manner.

Orthographic processing deficits. This theory defines dyslexia as being brought about by a deficit in orthographic processing. Orthographic processing, according to the connectionist model, refers to an individual's ability to recognize letters and words by their visual characteristics, such as size, shape, and contrast (Badian, 1997). It is usually measured through rapid automatic naming tasks, which generally require participants to read words, letters, or the names of pictures aloud as quickly and accurately as possible. While it is true that orthographic knowledge develops in part from repeated exposure to text, not all children exposed to the same amount of print will have the same orthographic processing ability. Obrien, Wolf, Miller, Lovett, and Morris (2011) stated that poor readers need, on average, 9 exposures to new words, while proficient readers of the same age need approximately seven exposures. They examined the effect of increasing the number of exposures to new words in dyslexic children on rapid automatic naming tasks. They found that while increasing the number of exposures did not affect scores on rapid automatic naming tasks. The authors speculated that this was due to another level of skill involved in orthographic processing that was more than simple automatic recognition of words. Similarly to O'brien et al (2011), Fernandez, Vale, Martins, Morais, and Kolinsky (2014) found that in dyslexic children who are familiar with letters, letter knowledge and rapid naming do not fully explain orthographic processing.

Mixed causes. Phonological and orthographic processing are not mutually exclusive, as children can have deficits in both simultaneously (Badian, 1997; Olson, 1994). Children with deficits in both of these processing areas are referred to as children with a double-deficit, or mixed dyslexia. Badian (1997) predicted that there would be four general groups of readers: 2 groups with single deficits (i.e. only a phonological or orthographic deficit), one group with no deficit, and one group with the double deficit. Badian (1997) examined children identified with dyslexia and children with normal reading abilities and compared their scores on phonological and orthographic tasks. When paired with younger children on the same reading level as the dyslexic children, Badian (1997) found significantly lower phonological and orthographic scores, which provides support for the double-deficit hypothesis.

Diagnosing Dyslexia

A child may be identified with dyslexia if the child is found to be of average cognition with a weakness in an area of cognitive processing related to reading, such as auditory processing, visual processing, or processing speed. Early diagnosis may reduce the severity of the learning disability later in life and if dyslexia is not identified before grade 12 is over, accommodations may not be given in time to follow the student to post-secondary school. Generally speaking, the person conducting the evaluation will differentiate dyslexia from other neurobiological disorders and ensure that the child has had access to adequate education. Berninger (2014) suggests a three-step model to the differential diagnosis of specific learning disabilities. The first step is to rule out other possible explanations. The author states that the child must be at normal IQ as well as in the average range in five developmental domains: memory, language, social-emotional, sensory-motor, and attentional executive function. The child must have no co-occurring conditions. It is also important to look at other factors, such as the child's culture, education history, and family differences. For example, a child may not be struggling to read because of a neurological deficit if his parents never read to him or her when he or she was young. In this case, the reading deficit could be due to lack of exposure to text. According to Berninger (2014), the second step to the differential diagnosis of dyslexia is assessment. This assessment is separate from the assessment used to determine the discrepancy between reading ability and IQ in that the assessment here is used to determine exactly where the child's difficulty in reading lies. The author suggests giving a measure for listening comprehension, oral language expression, reading comprehension, and writing skill. The final step of this model is to make the diagnosis, using all of the information gathered in the previous steps.

Current Interventions for Dyslexia

There are hundreds of intervention programs that are marketed to educators; some are evidence-based, while some are not. Berninger (2014) suggests that students should receive their entire usual, grade appropriate instruction, with the addition of specialized phonological coding instruction. Kast, Baschera, Gross, Jancke, and Meyer (2011) found that extended practice in phonological coding leads to increased word recognition, while Eklund et al (2014) found that spelling training enhances reading skill in dyslexic readers. The International Dyslexia Association suggests that treatment programs include the following components: Phonological awareness training, vocabulary development, reading comprehension skills training, beginning and advanced decoding skills, and reading fluency (Henry, 2007). The trend in many reading interventions for children with dyslexia is to use a multisensory approach. This idea stems from the theory that dyslexia is due to a deficit in phoneme-grapheme association. The multisensory approach increases the amount of information associated with a grapheme from just phonology to color, shape, texture, sound, and tactile feedback. The authors of this study argue that since much of our information is learned through multiple senses in nature, it makes sense to learn to read this way. The extra information surrounding the multisensory approach can increase phonological awareness, which is an essential ability of skilled readers. In this study, the authors used a phoneme-grapheme matching (PGM) task that did not include use of the multisensory software. The children with dyslexia who used the software reduced their errors by 154% compared to their peers who did not practice with the software. On top of this increase in performance, children without dyslexia were also able to benefit from the software. Since both dyslexic and non-dyslexic students were able to benefit from the multisensory software, it would make sense to incorporate multisensory software into regular curriculum. While this program is useful for treating children with dyslexia, it is a relatively complex intervention. Other interventions have been suggested, and are founded on the same basic idea as that described in Henry (2007), which is to increase the amount of information associated with each letter to better aid in grapheme discrimination.

Font Interventions for Dyslexia

Over the years, many studies have examined the use of different fonts, or typefaces, as an intervention for children with dyslexia. These studies have identified three main areas in which a typefaces can aid the reading of a child with dyslexia, which are: size, spacing, and more distinct graphemes associated with the aesthetics of different font styles (Bernard, Chaparro, Mills, & Halcomb, 2003; Chung, 2002; Perea, Panadero, Moert-Tatay, & Gomez, 2012; Rudnickey & Kolers, 1984).

Font size. The size of a typeface is generally indicated by its point-value. A point is the smallest unit of measure in typography, and is equal to .353 millimeters or 1/77th of an inch. Twelve points make one pica, which is equal to 1/6th of an inch. The pica is generally used for measuring line width. Other studies measure font size by using x-height. X-height is the height of a lowercase letter that does not have a long vertical (e.g. m, n, or o). Put simply, the x-height is generally measured by the height of a lowercase 'x.'

Several studies have examined the effect of size on font readability, with varied results. In the seminal study of font size, Tinker (1963b) took approximately 900 fourth, fifth, seventh, and eighth graders and had them read in varying font sizes compared to a 10pt control. He found that fourth and fifth graders read best in 12pt font, and read worst in 6pt and 14pt font. He found that seventh and eighth graders read best in 10pt font, and also read worst in 6pt and 14pt font. This study, along with Bernard, Chapparro, Mills, and Halcomb (2003) shows that increasing font size is only effective subjectively after point sizes are higher than 12.

Bernard, Chapparro, Mills, and Halcomb (2003) examined the effects of font type, size, and presentation on computer screens. They examined Arial against Times New Roman, 10pt against 12pt font, and dot-matrix against anti-aliased presentation. Anti-aliased presentation appeared to be slightly wider and more bolded than dot-matrix presentation. They found that there was no objective effect between 10pt and 12pt font, nor was there an effect of font type or presentation. Their participants did, however, self-report that they preferred to read in 12pt Arial, followed closely by 12pt Times New Roman.

Cornelissen, Bradley, Fowler, and Stein (1991) examined both children with and children without visual processing difficulty. The authors had these children read word lists in which the font size got progressively smaller. They found that both children with and without visual impairment made fewer errors when the words were smaller and more errors when the words were larger. Perhaps unsurprisingly, they also found that children with visual processing difficulties made more errors than children without, regardless of font size. This article appears at first glance to be in direct conflict with the previous two studies. This study, however, examined word lists rather than words in context, like the other two studies. It is possible that increasing font size helps readability at the word level, but not at the sentence or passage level.

Spacing. Some studies have examined the effects of intra and inter-word spacing, as well as the effects of spacing between lines, which is also known as leading (Bloodsworth, 1993). Chung (2002) had six adults read short sentences spaced at 1x, 1.4x and 2x normal spacing. She found no differences in reading speed between the three conditions. In a Spanish study, Perea, Panadero, Moret-Tatay, and Gomez (2012) examined the effects of intra-word spacing on word identification speed and speed of reading text. They found that second and fourth graders without dyslexia identified words significantly faster when the words were more spaced out. This produced a medium effect ($\eta^2 = .12$). They also found that second and fourth graders with dyslexia identified words even faster when they were spaced out than their non-dyslexic peers ($\eta^2 = .45$). Perea et al (2012) did not find any effect of spacing on the speed of reading text. Inadequate leading has been shown to increase the chances of ‘doubling,’ or re-reading a line and skipping lines in children (Burt, 1959). Paterson and Tinker (1932) found that the ideal lead is two points. They found no effects for zero or one point leads, and reduced legibility for four point leads. These studies highlight the lack of literature surrounding the effect of spacing on the accuracy of reading text.

More distinguishable graphemes. Several studies have highlighted the importance of making individual letters as distinguishable from each other as possible. One way that has been used for many years is the serif. Serifs are small strokes attached to the ends of letters. Fonts without serifs are referred to as san-serif. For example, the letter 'A' in Times New Roman has two small extra strokes at its base, while the letter 'A' in Arial does not. The literature on the effectiveness of serifs at increasing font legibility is conflicting. Coronel-Beltran and Alvarez-Borrego (2010) examined Times New Roman and Arial using nonlinear invariant digital correlation. Put simply, this technique gave them a peak-to-correlation energy (PCE) that was equal to 1 / reaction time. They found that Times New Roman had consistently higher PCE values, which indicated readers would identify letters faster in Times New Roman than in Arial. Tinker (1963a) identified several other factors that increase the legibility of individual letters:

- The letter 'Q' should have a slight curve at the bottom.
- Letters openings should be made wide to avoid confusion with similar letters, such as C and O.
- Letters should not be narrow, especially A, V, X, and Z.
- Heavy serifs should be avoided.

Tinker (1963a) further polled 200 college students on their preference of font styles. They reported much disagreement on what font they preferred. Although many of the fonts Tinker (1963a) asked about are no longer in use, it demonstrates the fact that aesthetic preference for a font doesn't necessarily mean the font will be more legible. Sheedy, Subbaram, Zimmerman, and Hayes (2005) conducted four experiments, among which they examined the effect of font type on legibility. Of the six fonts they tested (Georgia, Times New Roman, Plantin, Verdana, Arial, and Franklin), they found that the two most legible fonts were Verdana and Arial, while the least legible fonts were Times New Roman and Franklin. Verdana, Arial, and Franklin are sans-serif fonts, while Times New Roman is a serif font. These results did not allow for Sheedy et al. (2005) to make any statements regarding the general legibility of serif versus sans-serif fonts. Sheedy et al. (2005) also examined boldface and italic characters and their effects on legibility. They found that bolder characters were more legible than non-bold characters and that italic characters were less legible than non-italic characters.

The Use of Specialty Fonts

Recently, there has been some movement in the literature towards using specially-made fonts for students with reading disability. Despite the conflictual nature of the literature regarding what about fonts make them more legible, several font styles have surfaced. For example, Zascavage, McKenzie, Buot, Woods, and Orton-Gillingham (2012) designed a font that appears three-dimensional. They examined the legibility of words with this font using 214 emergent first-grade readers. They found that the lowest-performing ten percent of their sample had at least a ten percent increase in accurate word identification when switching from the flat-font to their specialized three-dimensional font.

Dyslexie. Another specialty font was created by Boer (2012). The font, referred to as 'Dyslexie,' has been studied in Dutch populations of children. These studies have examined Dyslexie's legibility both at the single-word and the passage level. Dyslexie has an increased x-height, and as such is larger than many standard fonts. In fact, 12 point Dyslexie is equivalent in size to 14 point Times New Roman or Arial. For inter-word spacing, Dyslexie is equal to double-spacing after each word in a sentence when typing in Times New Roman. Further, Dyslexie's lead is equivalent to spacing Times New Roman or Arial multiple at 1.7. According to Boer (2012), Dyslexie's aesthetic style will lead to fewer of the common errors made by people with dyslexia, such as mirroring, rotating, and switching letters in text. The font itself has several aesthetic characteristics that Boer (2012) claims will reduce these errors. For example, the base of each letter is more bolded than the top in order to prevent rotation errors. To prevent mirroring errors, the loops of orthographically similar letters, such as 'b' and 'd,' are visually distinct such that if the letter were to appear flipped, it would not be an exact match for the corresponding letter. For example, a flipped 'b' in Dyslexie would have a loop that is distinct from the 'd' in Dyslexie.

So far, only a few studies have examined Dyslexie's legibility, and even fewer have looked at its utility in children with dyslexia. De Leeuw (2010) examined 43 students from the University of Twente in the Netherlands. Approximately half of these students were diagnosed with developmental dyslexia, while the other half were identified as normal readers. Neither group had other diagnoses, such as Attention-Deficit Hyperactivity Disorder (ADHD) or other learning disabilities. De Leeuw (2010) had his participants each read two rapid automatic naming tasks. One task contained a list of real words, while the other contained a list of pseudo-words. Each task required the participant to read the words aloud as quickly and accurately as possible. Each task had two versions, and each version was printed in either Arial or Dyslexie. To control for font size, the author set the Arial font to be 14 points. The author assigned participants to one of four conditions:

- Version A of both tasks in Arial, then Version B of both tasks in Dyslexie.
- Version A of both tasks in Dyslexie, then Version B of both tasks in Arial.
- Version B of both tasks in Arial, then Version A of both tasks in Dyslexie.
- Version B of both tasks in Dyslexie, then Version A of both tasks in Arial.

De Leeuw (2010) found that Dyslexie did not increase reading speeds for normal readers nor did it for participants with dyslexia. He did, however, find that participants with dyslexia made fewer errors when reading real words when reading in Dyslexie than when reading in Arial. Participants without dyslexia, however, performed worse when reading in Dyslexie than when reading in Arial. These differences, while statistically significant, are practically very small. Participants with dyslexia, on average, made less than one more error in a two minute rapid automatic naming task when reading in Arial, and normal reading participants made, on average, less than one more error in the same task when reading in Dyslexie.

Pijpker (2013) conducted a similar study, but instead of utilizing rapid automatic naming tasks, she examined Dyslexie's legibility in short passages. Pijpker split the sample of 64 children into four groups. Twenty-two children were identified as 'dyslexic' using a screener that provided a cognitive profile for dyslexia. The screener involved the use of several rapid automatic naming tasks that required participants to identify words, colors, letters, and images. This group, as well as the remaining 44 children, was further split into 'low' and 'high' reading levels using their scores on the screener. None of the participants had ADHD or other learning disabilities. Those participants in the higher reading level group read texts that were slightly longer and more difficult. Pijpker (2013) used eight short texts from a Dutch teaching method. Four of the texts were read by the lower reading level participants, and four were read by the higher reading level participants. The author used Flesch Reading Ease scores (Flesch, 1948) to equalize the texts in terms of readability. Since Pijpker (2013) was also examining the effect of the paper's color on text legibility, and each participant read four stories, the author assigned participants to one of four groups to control for order effects. The author did not, however, control for the order of the stories, as they were in a fixed order. Pijpker (2013) found no significant differences between participants with dyslexia and normal reader in terms of reading speed for neither the high nor the low level groups. The author did, however, find that participants with dyslexia who were in the lower reading level group made, on average, ten less errors in the stories when reading in Dyslexie.

Perhaps the most relevant findings in the efficacy of Dyslexie come from the results of Marinus et al (2016). The authors of this Australian study examined Dyslexie within the context of word reading fluency in 39 low-progress readers in the 2nd through 6th grade. They sought to isolate characteristics of Dyslexie that potentially aid readers through the use of four conditions: (1) Dyslexie as it was designed, (2) Arial font matched for size with Dyslexie, (3) Arial font matched with size and inter-word spacing with Dyslexie, and (4) Arial font matched with size, inter-word spacing and intra-word spacing. They found that condition one (Dyslexie as it was designed) outperformed conditions two and three. The authors found no significant differences between conditions one and four, however, which suggests that when size and spacing is controlled for, the reading fluency benefits of Dyslexie dissipate.

These studies encapsulate the conflicting nature of the literature on interventions for dyslexia. From these studies, it appears that students with dyslexia read slightly more accurately when reading individual words. It would also appear that those with dyslexia who are also on the lower end of the spectrum of reading ability make considerably fewer errors when reading in Dyslexie as compared to the unaltered versions of common fonts. These studies also highlight significant gaps in the literature.

Present Study

The current study seeks to fill some of these gaps in the literature on Dyslexie. To date, Dyslexie has not been examined in an American population of school-aged children identified by a school psychologist (or other certified professional) as a child with a specific learning disorder in reading. Further, previous literature has not compared Dyslexie to a serif font, such as Times New Roman, nor has it examined both rapid automatic naming tasks and words in context simultaneously. Previous literature is missing what is arguably the most important element of reading, which is comprehension. Finally, previous literature has not examined Dyslexie in light of scores from orthographic processing tasks. Children who perform poorly on orthographic tasks are, theoretically, prime candidates for an intervention in which the font of the text is altered.

If it is found that an intervention as simple and cost-effective as altering the font in which printed material is presented in, there would be several very positive implications for school officials. We have three hypotheses and two research questions:

1. Participants will make fewer errors when reading Dyslexie than when reading Arial or Times New Roman.
2. Participants will comprehend text better after having read a story in Dyslexie than in Arial or Times New Roman, as measured by participant scores on comprehension questions.
3. Will participants read faster in Dyslexie than in Times New Roman or Arial?
4. There will be a negative correlation between orthographic ability, as measured by the orthographic composite from the FAR and the number of errors made when reading in Dyslexie, Times New Roman, and Arial.
5. The negative relationship between participants' scores on the FAR orthographic subtest and participants' dysfluencies in Dyslexie will be stronger than the relationship between the participants' orthographic scores and dysfluencies in either Times New Roman or Arial.

Method

Participants

The participants of the current study included 36 fourth and fifth graders who attend school in two rural counties in Virginia. Our sample was 66% boys, and 52% were 5th graders. The boys and girls ranged in age from 8-12 (*M* = 10.34, *SD* = .95). We obtained half of our participants from each of the two counties sampled.

The researchers, who were school psychologist interns and practicum students of the system in which the participants were gathered, identified all participants through a review of educational records. We obtained parent consent from each child's parent or guardian through a letter that was sent home with each child. All participants in the current study were identified as students with a Specific Learning Disability through a previous evaluation conducted by the school system that they attend and have a specific academic weakness in reading. Students with more generalized academic weaknesses (e.g. reading and math, reading and writing, reading, math and writing, etc.) were excluded from the study. Students with comorbid disabilities, such as attention-deficit hyperactivity disorder (ADHD), were excluded from participation. All of the participants were native English speakers and all had normal or corrected to normal vision.

Test Instruments and Materials

Feifer Assessment of Reading. The Feifer Assessment of Reading (FAR, Feifer & Nader, 2015) is a standardized cognitive assessment designed to measure reading ability in children and young adults aged 4-21. In the current study, the researchers used two composites from the FAR; the Rapid Automatic Naming subtest and the Orthographic Processing subtest.

Rapid automatic naming (RAN). The RAN subtest is comprised of two tasks that required the participant to quickly say the names objects on a page. The first task displays pictures of various objects, such as a hat, duck, or clock, while the second task displays various letters written in stencil form. That is, the stenciled letters appear to be written as a dotted line. Word automaticity, measured by rapid automatic naming tasks, has been shown to predict both basic reading acquisition as well as reading ability in older children (Flanagan, Ortiz, & Alfonso 2013).

Orthographic processing. The Orthographic Processing subtest displayed a word to a participant for one second, then immediately followed with a selection of letters.

The participant was to pick the letter(s) that were in the word shown to them previously. If the participant progressed far enough, they would continue the procedure with made-up words, also known as pseudowords. Orthographic processing has been shown to predict reading ability in children of all ages (Flanagan, Ortiz, & Alfonso, 2013).

Reliability and Validity. Measures of internal consistency for the FAR range from .67 to .97. Feifer and Nader (2015) found a Cronbach's alpha of .79 for both fourth and fifth graders on the rapid automatic naming subtest. They found an alpha of .97 for fourth graders and .95 for fifth graders on their orthographical processing subtest. To measure concurrent validity, Feifer and Nader (2015) correlated subtest raw scores from the FAR with scores on several other tests of reading ability, such as the Process Assessment of the Learner – Second Edition (PAL-II Reading and Writing; Berninger, 2007), and the Gray Oral Reading Tests – Fifth Edition (GORT-5; Weiderhold & Bryant, 2012). The authors of the FAR found significant high positive correlations between the FAR and the PAL-II and the GORT-5. The authors also correlated the FAR with subtests from the Academic Achievement Battery (AAB; Messer, 2014). They found significant high positive correlations between subtests on the FAR and related subtest on the AAB, such as Word Reading Fluency, Oral Reading Fluency, and Irregular Word Reading Fluency.

Stories. For this study, the researchers wrote three stories modeled closely on those of the fourth grade level on the Qualitative Reading Inventory (QRI, Leslie & Caldwell, 2011). All three stories were biographical in nature. The stories were about three different historical figures: Davy Crockett, Rosa Parks, and Nikola Tesla (See

Appendices A, B, and C). Each story was 200 words long, and was put onto the fourth grade level using Flesch-Kincaid Grade Level scores. Flesch scores take into account the number of syllables per word and the number of words per sentence to determine the ease with which someone can read them. This number is then used to calculate the grade level that a student would be expected to have to read the passage easily (Flesch, 1948). The Flesch-Kincaid Grade Level is calculated using the following formula: .39(total words/total sentences) + 11.8(total syllables/total words) – 15.59. The three stories were each written in all three fonts: Arial, Times New Roman, and Dyslexie. In order to control for differences in size and spacing, both between words and between lines, stories written in Dyslexie were written in 12 point font, spaced normally between words and multiple at 1.2 between lines. Stores written in Times New Roman and Arial were written in 14 point font, double-spaced between words and spaced multiple at 1.7 between lines.

Comprehension Questions. Three comprehension questions were written for each of the three stories. They were modeled after those written in the QRI (Leslie & Caldwell, 2011). All questions were factual in nature and the answer was written somewhere verbatim in the text. For example, in the Davy Crockett story, the passage reads: “When he was a young man, he became very good at trapping bear and raccoons.” The corresponding comprehension question asks: “What kinds of animals did Davy trap?”

Distractor Tasks. The researchers created three distractor tasks for this study in order to aid in sustaining participant attention. Two of these tasks were block design tasks, modeled from the Wechsler Intelligence Scale for Children (WISC-V, Wechsler, 2014). Both block design tasks included blocks used in the Wechsler tests. The third distractor was a picture of a cat seemingly stuck in a tree while the humans and animals around the tree attempt to get it down. We also gave participants four RAN tasks as part of a separate study. One of the RAN tasks we used was an unmodified version of the word list from the Kaufman Test of Educational Achievement (KTEA, Kaufman & Kaufman, 2004). We created the other three word lists and each was modeled closely on the KTEA word lists. Of these lists, one contained pseudowords, and two contained real words. The real word lists were created using vocabulary lists from grades 1-7, with six words on each list per grade. The words were listed in ascending difficulty. Words on the pseudoword list were created using phonics rules obtained from phonics curriculum from grades 1-7. Words were created and listed in ascending difficulty. The researchers set the spacing between words to be equal, regardless of the font the lists were presented in. Lists presented in Dyslexie had 12 point font, while those presented in Times New Roman or Arial had 14 point font.

Procedure

We obtained assent from the participants by explaining the purpose of our study and having them write their name on an Assent Form. In order to check for inter-rater reliability, all data collections were audio-recorded. We brought each participant into a quiet room in their respective schools to conduct the testing. We asked several questions as a means of gaining rapport with the participant, such as, “What do you want to be when you grow up?”

Immediately following the short interview, we gave the participants the FAR rapid automatic naming and orthographic processing subtests. The RAN task required the participants to perform two tasks. The first task required participants to say as many of the names of pictures (e.g. hat, duck, clock, tie) from a large array as they could in 30 seconds. In the second task, we presented stenciled letters in a large array, each of which appeared to be written in dotted lines, to the participants. We instructed them to read as many of the letters as they could in 30 seconds. In the FAR orthographic processing subtest, we presented a word for one second, then removed it and presented several answer choices. The answer choices included possible parts of the word that we presented previously. For example, if we presented the word "attainment," possible answer choices might be, "tai," "tia," "tla," or "tal." Participants had as long as they needed to respond to these items. We scored both subtests from the FAR using the appropriate grade-norms and obtained standard scores for each subtest.

We then presented the KTEA list of words and instructed the participant to read as many words out loud as they can in one minute. We recorded both the number of correct and incorrect pronunciations.

Following the KTEA list, we gave participants the first distractor task, which was a block design task. We presented participants with a sheet of paper with a design modeled from the Wechsler series of cognitive tests, as well as blocks with. We allowed participants to take their time to complete the design, and did not correct them if they presented an incorrect design.

We then presented participants with the first story that they were to read. We asked each participant to read each story aloud as quickly as possible without making any mistakes and informed them that they would be asked several questions after reading the story. We recorded the amount of time it took each participant to read a story as well as the number of dysfluencies. If a participant misread a word but self-corrected, we did not count a dysfluency. Further, if a participant skipped a line in the reading, they were informed of their mistake and directed to the correct line of text to read from. Following the story, each participant answered three comprehension questions.

Following the comprehension questions, we presented participants with their next word-list. For each word-list task, participants were given one minute to read as many words from the list as they could. We recorded the number of correct as well as incorrect responses.

Immediately after the word list, we presented the participants with the ‘cat in the tree’ distractor task. We asked participants to examine the picture and tell us what they were seeing. We repeated this basic procedure (story, comprehension questions, word list, and distractor) two more times, with the exception of having no distractor task at the end of the last iteration. Since this study was dependent on the speed with which participants could read the stories, this procedure took participants between 20 and 35 minutes.

Identifying Dysfluencies. In order to obtain high levels of inter-rater agreement, we trained two undergraduate research assistants to review the audiotapes of our sessions. We trained our assistants to count dysfluencies whenever a participant mispronounced, misread, omitted, or added words. Words that seemed mispronounced but were reasonably attributable to dialect were not counted as dysfluencies. They completed this procedure on their own, then met to discuss their findings. We instructed the assistants to repeat this until they obtained perfect agreement for each tape. We took their findings under consideration when coding our sessions.

Counterbalancing. The order of the FAR subtests and the KTEA list were constant between participants. The order of stories, lists, and fonts, however, varied between participants. In order to reduce the number of participants required to control for order and fatigue effects, we counterbalanced the stories and fonts separately from the lists and fonts. The counterbalancing for the stories and fonts was such that every possible order of stories and fonts was given to different participants. For example, 12 of 36 participants began with Davy Crockett, 12 began with Rosa Parks, and 12 began with Nikola Tesla. Of the 12 that read Davy Crockett first, six read Rosa Parks second, and six read Nikola Tesla second. Those six who read Davy Crockett first and Rosa Parks second read Nikola Tesla third. The other six who read Davy Crockett first and Nikola Tesla second read Rosa Parks third. This procedure was repeated for those who read Rosa Parks first as well as those who read Nikola Tesla first.

We counterbalanced the word lists in a similar fashion. Of the 36 participants, 12 read real-list one (RL1) first, 12 read real-list two (RL2) first, and 12 read the pseudo-word list (PL) first. Of the 12 that read RL1 first, six read RL2 second, and six read PL second. The six that read RL1 first and RL2 second read PL third. The other six that read RL1 first and PL second read RL2 third.

Results

We conducted three independent samples t-tests to determine the equivalency of the participants' data from our two Virginian school systems. We chose three variables from different portions of our study to do this: errors committed while reading the story "Nikola Tesla," the number of words read correctly on our list in Arial, and standard scores obtained from the FAR orthographic subtest. We found no significant differences between participants from each system for errors committed while reading "Nikola Tesla" $t(34) = -0.124$, $p = .902$, on number of words read correctly on our Arial wordlist $t(15.774) = 1.863$, $p = .081$, or on standard score on the FAR orthographic subtest $t(34) = .187$, $p = .636$.

To examine the extent to which our participants made errors equally among the three stories, we conducted a one-way repeated measures ANOVA. We found that our stories differed significantly in the number of errors participants made while reading, $F(2, 70) = 5.623$, $p = .005$, $\eta^2 = .138$. Specifically, participants committed significantly fewer errors while reading "Rosa Parks" ($M = 19.69$, $SD = 12.06$) than while reading "Davy Crockett" ($M = 24.86$, $SD = 10.6$).

To analyze our first hypothesis, that participants will make fewer errors when reading Dyslexie than when reading Arial or Times New Roman, we conducted a one-way repeated-measures ANOVA. We found no significant differences in errors committed for Arial ($M = 22.91$, $SD = 13.22$), Times New Roman ($M = 22.13$, $SD = 11.64$), or Dyslexie ($M = 21.22$, $SD = 8.6$), $F(2, 70) = .522$, $p = .298$ (one-tailed). See

Figure 1.

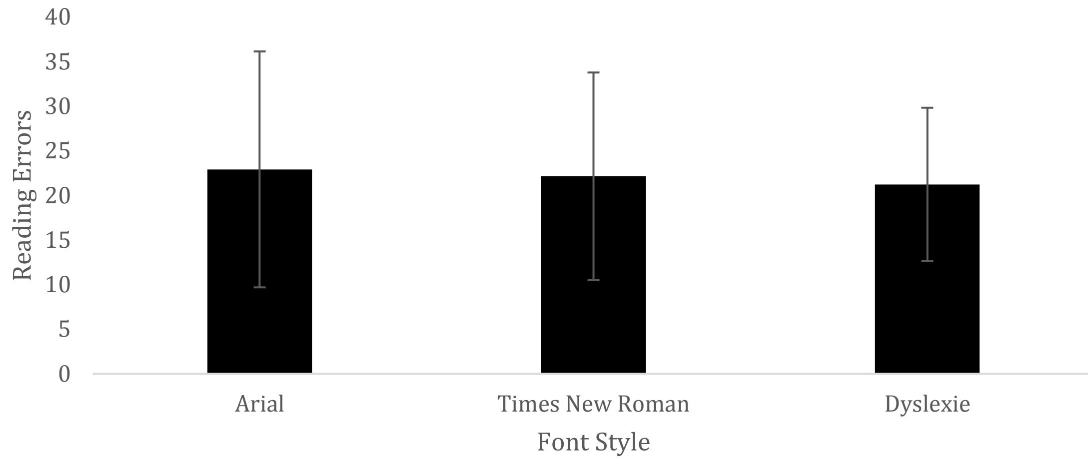

Figure 1. Reading errors by font style.

To analyze our second hypothesis, that participants will comprehend text better when it is written in Dyslexie than in Arial or Times New Roman as evidenced by participant scores on comprehension questions, we conducted a one-way repeated-measures ANOVA. We found no significant differences in the number of correct comprehension questions for Arial (M = 1.86, SD = .68), Times New Roman (M = 1.8, SD = .74), or Dyslexie (M = 1.8, SD = .74), $F(2, 70)$ = .111, p = .445 (one-tailed). See Figure 2.

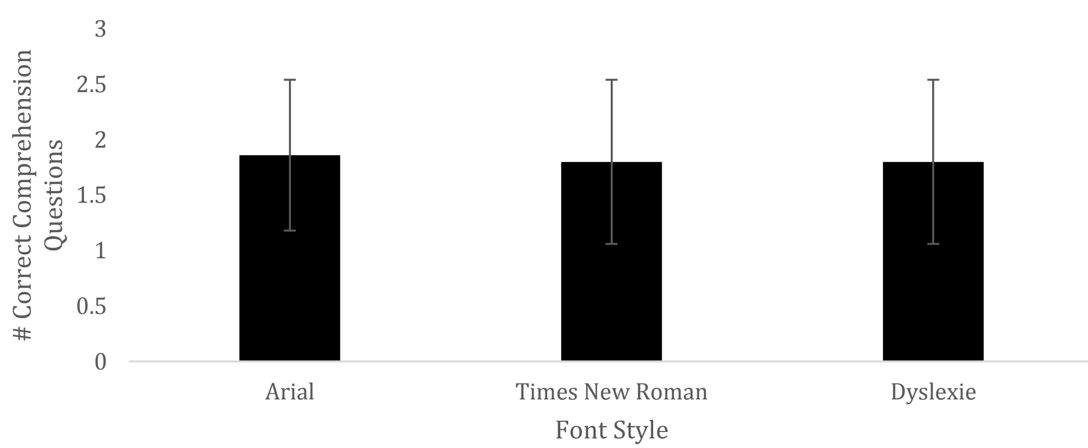

Figure 2. Number of correct comprehension questions by font style.

To analyze our first research question, which asks if participants will read faster in Dyslexie than in Times New Roman or Arial, we conducted a one-way repeated-measures ANOVA. We found no significant differences in the amount of time in seconds that participants took to read our stories in Arial (M = 202.11, SD = 76.48), Times New Roman (M = 213.44, SD = 96.0), or Dyslexie (M = 211.61, SD = 116.22), F(1.307, 45.729) = 1.031, p = .336. See Figure 3.

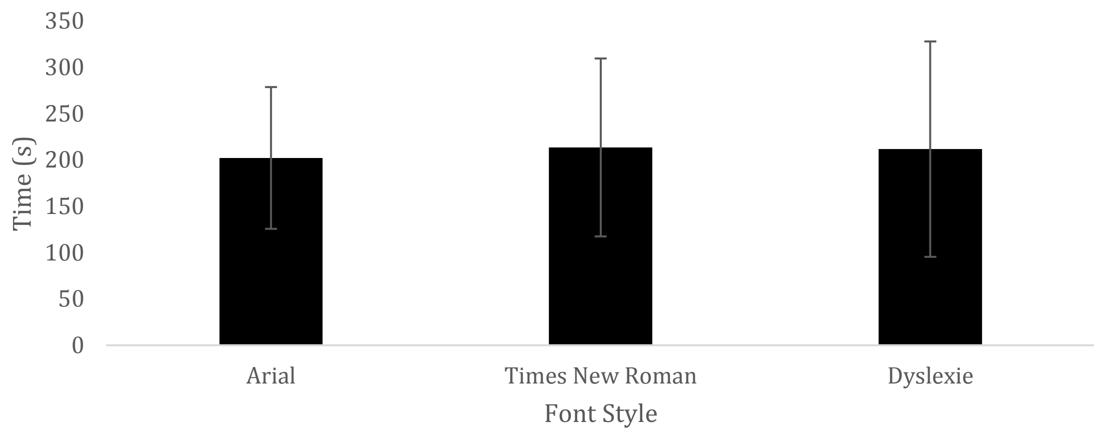

Figure 3. Reading time in seconds by font style.

Our last two research questions ask about the relationship between our participants' scores on the FAR orthographic subtests and the number of dysfluencies they make while reading. We found no significant correlations between errors committed by font and orthographic scores on the FAR for Arial, Times New Roman, or Dyslexie. See Table 1.

	Arial	Dyslexie	Times New Roman	Far Orthographic
Arial	1	.728**	.640**	.0003
Dyslexie		1	.543**	.023
Times New Roman			1	-.006
Far Orthographic				1

Table 1. Correlations between font styles and participants' orthograhpic scores.

Discussion

Overall, we did not find support for our hypotheses. While few studies have examined the effects of specialty fonts for dyslexia, several studies have demonstrated, with conflicting results, the effects of more distinguishable graphemes on readability. Some studies have found that readers identify words more quickly when reading serif fonts, such as Times New Roman, than while reading sans-serif fonts, such as Arial (Coronel-Beltran &Alvarez-Borrego, 2010). Sheedy et al. (2005) examined seven fonts, and concluded that the two most readable fonts were sans-serif, while two of the least readable for sans-serif, which did not enable the authors to make a conclusive statement on the readability of serif versus sans-serif fonts.

Tinker (1963b) proposed several characteristics of font that have largely been incorporated into modern computerized fonts, such as:

- The letter ‘Q’ should have a slight curve at the bottom.
- Letters openings should be made wide to avoid confusion with similar letters, such as C and O.
- Letters should not be narrow, especially A, V, X, and Z.
- Heavy serifs should be avoided.

While Dyslexie clearly follows these guidelines, it appears that solely exaggerating the differences between letters, such as ‘d’ and ‘b’, does not have effects on readers’ fluency, accuracy, or comprehension.

Our first analysis, which examined the number of errors each of our participants made while reading in the three fonts, found no differences between Arial, Dyslexie, and Times New Roman. This finding is discrepant with de Leeuw (2010) and Pijpker (2013), who each found Dyslexie to be superior in readability to Arial, but only in specific conditions. Pijpker (2013) found that participants with a lower reading level and dyslexia made fewer overall errors while reading in Dyslexie than while reading in Arial. De Leeuw (2010) found that participants with dyslexia made fewer errors while reading in Dyslexie than when reading in Arial. Participants without dyslexia, however, actually performed worse when reading in Dyslexie than when reading in Arial. These differences found by de Leew (2010), while statistically significant, are practically very small. Participants with dyslexia, on average, made less than one more error in a two minute rapid automatic naming task when reading in Arial, and normal reading participants made, on average, less than one more error in the same task when reading in Dyslexie.

There is conflicting support in the literature of a positive relationship between the size and spacing of a font and the legibility of that font (Bernard, Chapparro, Mills, & Halcomb, 2003; Parea, Panadero, Moret-Tatay, & Gomez, 2012; Tinker, 1964b). As such, it appears that when those variables are held constant, Dyslexie's effect on readability disappears. Bernard et al (2003) compared Times New Roman to Arial in 10pt and 12pt font, and found no objective differences between either of the fonts in either size. They did find that participants subjectively preferred 12pt to 10pt in both fonts. Tinker's (1963b) fourth and fifth grade participants read best in 12pt font, and worst in 6pt and 14pt font. His older participants, who were in seventh and eighth grades, read best in 10pt font. Parea et al (2012) took several passages and increased the spacing between words. They found a medium effect in non-dyslexic second and fourth graders' reading accuracy, and found a more pronounced effect in children with dyslexia. They found no effect of inter-word spacing on reading speed. While the current study did not manipulate font size as a variable, it is possible that any benefit of Dyslexie may lie within its increase size, inter-word spacing, and intra-word spacing.

Our participants displayed no differences in their ability to answer comprehension questions after reading the stories in various fonts. While the creators of Dyslexie make no claims that it aids student comprehension, it stands to reason that a font designed to be more legible would allow a reader to retain more information than they would in a less legible font.

We also sought to examine the speed with which our participants read. We found no differences by font in the reading speed of our participants. It appears that Dyslexie does not increase the speed with which students read words in context. These findings are consistent with Marinus et al (2016) who similarly found that when size, inter-word, and intra-word spacing are controlled for, Dyselxie does not benefit readers' fluency as measured by words per minute. While we found no benefits after controlling for size and spacing, Marinus et al (2016) found significantly faster reading times while comparing un-altered Arial to un-altered Dyslexie. This indicates that there is a benefit of increasing a word's size and spacing to readers' fluency, as opposed to the other orthographic properties of Dyslexie.

We found no significant relationships between our participants' orthographic ability and the errors they made by font. Orthographic processing refers to the ability to recognize letters and words by their visual characteristics, such as size relative to other letters, shape, and contrast (Badian 1997). Despite our findings, the literature offers support for the existence of orthographic processing. Obrien et al (2011) examined the effect of increasing the number of exposures to new words in dyslexic children on rapid automatic naming tasks. They found that increasing the number of exposures did not affect scores on rapid automatic naming tasks. The authors speculated that this was due to another level of skill involved in orthographic processing that was more than simple automatic recognition of words. Similarly to O'brien et al (2011), Fernandez, Vale, Martins, Morais, and Kolinsky (2014) found that in dyslexic children who are familiar with letters, letter knowledge and rapid naming do not fully explain orthographic processing. Our analysis of the relationship between our participants' errors made while reading and orthographic processing may be insignificant due to a small sample size.

Limitations

Although we designed our stories to be equivalent using the Flesch-Kincaid Grade Level Scale (Flesch, 1948) and close modeling of the Qualitative Reading Inventory (Leslie & Caldwell, 2011), our story entitled "Rosa Parks" was significantly easier for our participants to read than our story entitled "Davy Crockett" as evidenced by significantly fewer errors while reading the former when compared to the latter. We believe that had we even found marginal significance in our errors by font analysis, this difference in stories may have raised questions as to the source of variability that caused the differences in errors by font. However, due to our non-significant findings, we believe that this limitation does not interfere with our interpretation of the results.

The current study utilized a sample of 36 fourth and fifth grade students. While this sample is small compared to many intervention efficacy studies, it is a comparable and even larger sample than those of others who have examined Dyslexie. As a byproduct of our experimental controls, our sample was quite narrow in its scope. We asked only fourth and fifth graders identified with specific learning disorder in reading with no co-morbid conditions to participate, which may hinder the generalizability of our findings to older, younger, or more diverse samples of students.

Ideally, our sample would have consisted of only readers who possess processing deficits in orthographic processing. Unfortunately, identifying those students ourselves would not be possible within our time-constraints. Theoretically, the only students who would benefit from an intervention such as Dyslexie would be those who have difficulty processing the orthographic information (i.e. graphemes) that they see, and not those who have difficulty with letter-sound (i.e. grapheme-phoneme) associations. It is possible that, given a sample of participants who purely have orthographic difficulty, effects for Dyslexie would be found.

Directions for Future Research

It is possible that Dyslexie has a subtle effect that is only noticeable over longer reads. As such, future studies should utilize similar methods to examine the use of Dyslexie compared to other fonts in longer passages. Since we examined a small, specific minority of students, it may be useful to examine Dyslexie's utility with older students and students without dyslexia. It is also possible that Dyslexie's effect is only present in a reader who is familiar with the font. An extended study, in which participants were exposed to the font over some period of time, may show an effect.

Previous studies (i.e. Marinus et al, 2016) have found evidence for a relationship between font size/spacing and fluency. Future studies should examine the extent to which font size and spacing affects readers' fluency, accuracy, and comprehension. Such a study would utilize a similar design as the current study while varying font size, inter-word spacing, and intra-word spacing in order to find optimal settings for these characteristics.

Conclusions

Dyslexie, when compared to other common fonts that have been adjusted to control for Dyslexie's large size and spacing, appears to have no effect on readers' ability to read text correctly, comprehend text, or read faster. This conclusion does not support the use of a specialized font to aid students with lower orthographic ability. Van Someren (2013) used a self-report questionnaire and found that participants felt Dyslexie aided them while reading and that they enjoyed reading with the font. While Dyslexie did not aid participants in their reading when compared to altered Arial and Times New Roman, it was not detrimental. Based on the current study, there is no indication that Dyslexie would disrupt readers, and that if readers prefer the aesthetic characteristics of Dyslexie, it appears that they can use it without negative consequences.

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Appendix A

"Davy Crockett"

Davy Crockett was born in a log cabin in Tennessee. He was a trapper, soldier, and lawmaker. When he was a young man, he became very good at trapping bear and raccoons. Davy was famous. He was famous for wearing a raccoon-skin hat on top of his head. He married Mary Polly Finley when he was 20 years old. They had two sons, John Wesley and William Finley.

When he was 27, Davy joined the US army. He served under Andrew Jackson. He fought Indians in the south east US. Sadly, Davy's wife died in 1815. Later, he married Elizabeth Patton. She was a widow that had two young children.

Davy left the army. He served in his state House for three years. After that, he was in the US House for six years. He lost his last election in 1836. He moved to Texas. Texas had just declared its freedom from Mexico when he got there. Davy Crockett died in 1836. He was trying to defend the Alamo. The Alamo was a mission in a big town in Texas. The phrase "Remember the Alamo!" was a battle cry used by Sam Houston. Sam Houston later won freedom for Texas.

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Appendix B

"Rosa Parks"

Rosa Parks was born in Alabama. She was born in 1913. She is known around the world as the Mother of Civil Rights. Rosa's mom was a teacher and taught Rosa. When she was 11, she moved to finish school. Before Rosa could finish, her mom got sick and Rosa left school to take care of her. She met her husband in 1932. He helped Rosa finish school.

Rosa was a famous civil rights activist and a member of the NAACP. During that time, black people had to get up if a white person asked them to on the bus. In the winter of 1955, Rosa Parks bravely stood against that rule. The police took her away, but Dr. Martin Luther King, Jr. heard the news. He started the Montgomery Bus boycott. In a boycott, a group of people don't buy something because they don't agree with the people who are selling that thing. After a year, the courts made a decision. They decided that telling people where to sit on the bus was not legal. This led to more fairness for black people. Rosa went on to help people who did not have houses find a place to live.

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Appendix C

"Nikola Tesla"

Nikola Tesla was born in 1856. He was not born on the US. His mom was an inventor. She made things for women who stayed home to make house work easier. Tesla liked his mom's inventions. Tesla helped her with them a lot. His father was a priest and wanted Nikola to be one too. He said no because he wanted to be an inventor.

When he was 28, Nikola moved to the US. He began working with Ben Franklin. Franklin was an inventor and did a lot of business. After a year, they stopped working together. They stopped because they did not get along. After this, Nikola needed to find new people to help him pay for his inventions.

He invented a new way to power things. In fact, Tesla's system is what powers our lights today. In 1888, a man bought Tesla's system. In 1895, Tesla created the first power plant. It used water to make power. It powered a whole city by itself. He also made the Tesla Coil. The Tesla Coil let other people make a lot of the things that we use today. We have Mr. Tesla to thank for radios, remote controls, and X-rays.

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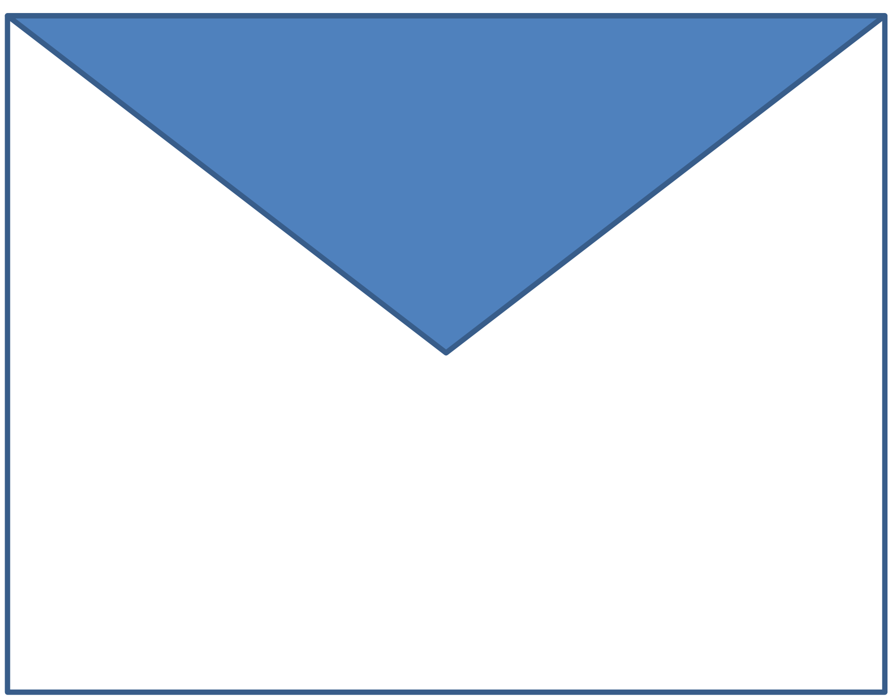
Appendix D

Block Design 1

Block Design 2



Appendix E