The Effects of Altered Font for Students With and Without Decoding Difficulties

By

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DEDICATION

To my mother who taught me that it was ok to hold my own hand when crossing the street.

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ABSTRACT

Dyslexia fonts have existed for nearly 20 years. These fonts were designed for readers with dyslexia to make it easier for them to read. Some advocates claim that these specialized fonts mediate the effects of dyslexia, while critics point out the lack of research showing their effectiveness and the high costs of accessing the fonts. Current research on altered fonts shows mixed effects. This research aims to extend the existing research base on altered fonts for students with dyslexia. In a recent meta-analysis, Shewalter et al. (2023) found relatively few studies that have measured reading accuracy or rate in deep orthographic languages like English. Even fewer studies have measured reading comprehension using altered fonts. Therefore, this study measured the effects of altered fonts compared to standard fonts on reading accuracy, reading rate, and reading comprehension for students with and without decoding difficulties. The study implemented a within-subject quasi-experimental design with participants from grades 3, 4, and 5 from a public elementary school in Tennessee. Participants read word lists and passages printed in five different font types: Times New Roman (TNR), TNR with added spacing, Arial, Arial with added spacing, and OpenDyslexic font. By utilizing altered and unaltered fonts that vary in characteristics (e.g., serif/sans serif type style, added spacing), the study attempted to parse out the effects of the individual font characteristics.

Keywords: dyslexia, altered font, OpenDyslexic, rate, accuracy, orthography, reading disabilities

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CHAPTER I: INTRODUCTION

Dyslexia and altered fonts have existed for nearly two decades, yet the research continues to be mixed on their effectiveness. They were designed specifically for readers with dyslexia to make it easier for them to read since individuals with dyslexia tend to struggle to read words accurately and fluently. Although interventions that address the individual's specific needs (e.g., systematic, and explicit phonics) are the most widely accepted and beneficial means of remediation (Ehri et al., 2001), font alteration is proposed to increase students' ability to access text immediately and provide greater exposure to print (Zorzi et al., 2012). The inability to access print impedes students' ability to gain important knowledge from text, including vocabulary knowledge, which in turn leads to greater consequences on comprehension ability (Stanovich, 1986). As their typically developing peers continue to show greater gains in reading, struggling readers continue to fall further and further behind, which was coined as the Matthew Effects (Stanovich, 1986). While not intending to replace efficacious reading interventions, if effective, altered fonts could be a practical accommodation for improving access to text for those who struggle to read efficiently.

Dyslexia Specific and Altered Font Characteristics

Common characteristics of dyslexia fonts are a sans serif font type, uniquely shaped letters, heavier markings at the bottom of the letters, and added spacing within and between words. Other typical fonts have also been altered to resemble these dyslexia specific fonts by modifying the boldness of the letters, adding spacing within words, or adding spacing between words. Each of these features is speculated to make reading less difficult for those who struggle to read, such as individuals with dyslexia. However, there is another factor that impacts the ability to read both accurately and fluently- the orthographic depth of the language.

Times New Roman (TNR) is a common font type that contains serifs. Serifs are the decorative lines added to the ends of letters. Sans serif font types do not have additional lines added to the letters. For instance, Arial is a common font that is considered sans serif. Dyslexia fonts utilize uniquely shaped letters, often with heavier and bolder lines at the bottom of letters. These markings make similar looking letters, like mirror images (e.g., b, d), more contrasting in their appearance. Spacing is typically added within words (i.e., inter-letter spacing) and between words (i.e., inter-word spacing). Reid et al. (2004) noted that spacing also posed a problem for beginning readers by creating visual crowding. The authors found that when certain letters followed other letters, they could easily be confused and provided the example of "rn" very closely resembling "m," which could be resolved with added spacing (Reid et al., 2004, p. 252). Dyslexia specific fonts also tend to be larger in size when compared to the same point size of a typical font. In the example below, OpenDyslexic 12-point font is comparable in size to TNR and Arial 14-point font (see Figure 1 below). Some examples of dyslexia font include Dyslexie, OpenDyslexic, and Easy Reading.

Common fonts such as TNR and Arial also can be altered to resemble dyslexia specific fonts by modifying the boldness of the letters, adding spacing within words, or adding spacing between words. For this research, reading accuracy, reading rate, and reading comprehension were compared in five different font types which have been matched in size: TNR unaltered, TNR with added spacing, Arial unaltered, Arial with added spacing, and OpenDyslexic font. By utilizing both altered and unaltered fonts that vary in characteristics, including serif/sans serif type style and added spacing, the study parsed out any potential effects of the individual font characteristics.

Example	Font Type
The dog catches the ball.	TNR 12-point font
The dog catches the ball.	Arial 12-point font
The dog catches the ball.	TNR with increased spacing 12 pt. font
The dog catches the ball.	Arial with increased spacing 12 pt. font
The dog catches the ball.	OpenDyslexic 12 pt. font

Figure 1. Examples of Font Types in This Research

Dyslexia and the Development of Specific and Altered Fonts

The idea of modifying fonts to improve the reading accuracy and rate of individuals with dyslexia transpired to address the visual processing differences and visual crowding thought to be associated with dyslexia (Joo et al., 2018). Visual crowding occurs during reading when an individual attempts to focus on words but is unable to distinguish single letters and will instead focus only on the beginning and ending of the word while the other letters merge, making them unrecognizable, which causes reading to be much slower and more labored (Bouma, 1970; Levi, 2008). Spinelli et al. (2002) pointed out that readers do not typically encounter isolated words but instead face many words on a single page of text while reading. The multitude of words creates a crowding effect for some readers (Spinelli et al., 2002). Joo et al. (2018) suggested that this could be problematic for some readers since effective reading requires adequate decoding of all the words on a page. These visual processing differences also prompted the notion of dyslexia causing confusion with similarly looking letters, especially those letters that are mirror images (e.g., b and d; Washburn et al., 2011). Although the idea that dyslexia occurs due to seeing letters and words backward has been debunked (American Academy of Ophthalmology, 2014; Moats, 1994; Washburn et al., 2011), issues related to visual crowding are being examined (Joo et al., 2018). Dyslexie font was designed to address these visual processing differences by creating uniquely shaped letters with added spacing (Boer, 2019).

Currently there are many altered fonts for dyslexia on the market (e.g., Dyslexie, OpenDyslexic, Easy Reading). One of the most popular is Dyslexie. Boer, a graphic designer, and an individual with dyslexia, created Dyslexie font specifically for those with dyslexia to help them to read (Boer, 2019). By creating letters with a unique shape and added spacing, the font type was thought to assist individuals with dyslexia in distinguishing between commonly confused letters and resolving the effects of visual crowding (Boer, 2019). In their call for a "friendly font", Reid et al. (2004) suggested that when children are learning to read and before they have mastered alphabetic knowledge, they should be exposed to a font type that has distinctive letters for learners to distinguish the difference between similar looking letters, numbers, and other symbols. The researchers also suggested that it could be confusing for children to be exposed to letters written in many different forms (Reid et al., 2004). For example, in print, the letter 'A' is usually type-written 'a' while children learn to write the letter as 'ɑ'.

However, Perfetti and Dunlap (2007) noted that although font characteristics might vary, the differences only exist on the surface since the form still represents a specific letter. In addition, O'Brien et al. (2005) pointed out that the position of the individual letters within the word matters too. The researchers noted that being able to identify a letter does not guarantee that a reader will be able to identify words and found that understanding the position of the letters within the word (e.g., “trap,” “tarp,” and “part”) allows the reader to identify the word correctly (O’Brien et al., 2005, p. 344). Ehri and McCormick (1998) pointed out that young children and older students with reading disabilities make reversal errors because they have not yet fully mastered alphabetical knowledge. Therefore, as children become more accurate with letter recognition, they also become more precise with letter-sound correspondence regarding specific letters. The question remains if alterations to the letterform (i.e., distinctiveness of the letters, added spacing) help these individuals read more efficiently.

Word Reading Development

Skilled readers are typically able to read words by sight. These readers have experienced the words within text before and the words are familiar. When a word is read by sight, the reader can access from memory how the word is spelled, how it is pronounced, and what the word means simply by looking at the printed word (Ehri, 1995). However, when a word is not familiar to the reader, the word can still be read using decoding strategies, analogy, or prediction (Ehri, 1995). Ehri (1995) described the developmental process of learning to read words by sight through five phases which include the pre-alphabetic, partial-alphabetic, full-alphabetic, consolidated-alphabetic phase, and automatic-alphabetic phase.

Beginning in the pre-alphabetic phase, Ehri (1995) noted that letters have no connection to the sounds that they represent. In this phase students rely on environmental print to associate letters/words with various objects (e.g., McDonald’s sign; Ehri, 1995, p. 118). At this point of development, students are not able to decode words and therefore depend on the visual aspects of the letters rather than the actual words (Ehri & McCormick, 1998). Without the visual aspects of the environment, the students are not able to read the words (Ehri & McCormick, 1998).

As students progress into the partial alphabetic phase, they begin to make associations between some letters and their corresponding sounds. Students often misread words based on the initial sound of the word or read words backwards as they have not yet mastered directionality in reading (Ehri & McCormick, 1998). Students in this phase often attempt to read words based on the initial and ending letters of the word while ignoring the middle letters (Ehri & McCormick, 1998). Likewise, this pattern is also how the reading of those experiencing visual crowding is described (Bouma, 1970).

During the full alphabetic phase, students can decode unknown words and use analogy to make sense of unfamiliar words (Ehri & McCormick, 1998). As students decode more effectively, they become faster and more accurate with their reading and more words are added to memory as sight words (Ehri, 1995). Ehri and McCormick (1998) noted that the only means of advancing to the next developmental phase is access to text to practice decoding and reading unfamiliar words which requires multiple repetitions to add those words to their lexicon.

Students tend to rely on larger units and strings of letters in the consolidated alphabetic phase, which allows readers to form relationships between words they know and those that they do not know and helps them to decode unfamiliar words (Ehri, 1995). Students also rely on common spelling patterns and morphological knowledge to help them to not only decode but also understand the meaning of the unfamiliar word, which is especially beneficial with irregularities within the English language (Ehri & McCormick, 1998).

Finally, in the automatic alphabetic phase, readers are able identify words accurately and effectively (Ehri & McCormick, 1998). Although readers may encounter unfamiliar words (e.g., non-medical personnel reading a medical journal), the reader possesses effective strategies for decoding and comprehension of the unknown word (Ehri & McCormick, 1998). Ehri and

McCormick noted that once a reader can read with automaticity, they use cognitive resources to focus on comprehension of the text rather than decoding individual words.

The Role of Orthographic Depth in Reading

Orthographic depth of a language can be characterized by the grapheme and phonemic relationship of the language (Carioti et al., 2021). In an alphabetic writing system, like English, each letter corresponds to a spoken sound or more than one sound (Perfetti & Dunlap, 2007). In other words, how the letters or spelling patterns match to the pronunciation of the sounds contributes to the orthographic depth of the language. If the letter-sound correspondence is one-to-one, then the orthographic depth is said to be shallow, such as Italian (Seymour et al., 2003). However, if the letter-sound correspondence varies, then the orthographic depth is said to be deep. English has a very deep orthography. A single letter or multiple letter combinations can be used for the same sound. For example, in English, the sound /ā/ can be spelled eight separate ways. What makes it even more confusing for young readers is that a specific string of letters can be decoded to make multiple sounds (e.g., 'ea' as in the words beach /ē/ and break /ā/). This variability can make learning to read exceedingly difficult even for the typically developing individual.

These inconsistencies of the letter-sound relationships in deep orthographies slow the development of reading skill (Schmalz et al., 2015). In fact, Seymour et al. (2003) suggested that learning to read in English takes twice the amount of time as learning to read in languages with transparent or shallow orthographies and impacts both real word and pseudo-word reading ability. Treiman and Kessler (2022) noted that developing readers use "statistical learning" to acquire a set of rules to understand the relationship between words in their written and spoken forms (p. 140). However, in languages with variability like English, the relationship is not as easily distinguished, and the patterns are not always explicitly taught through phonics instruction (Treiman & Kessler, 2022). In English, due to the inconsistencies of the letter-sound correspondence, individuals learning to read tend to rely on larger units and strings of letters to make these associations (Landerl et al., 2022). Examples of larger units include rimes (e.g., '-at' as in cat, hat, and fat) and morphemes (e.g., root words such as 'dog' or 'walk'; prefixes such as 'un-' or 'pre-'; suffixes such as '-able' or '-ed') which tend to be more consistent in the English language compared to single letter sound correspondence (Landerl et al., 2022; Ziegler & Goswami, 2005). As noted earlier, Ehri and McCormick (1998) termed this phase of learning to read as the "consolidated-alphabetic phase" or "orthographic phase" (p. 154). This phase of learning to read may be delayed up to two years for typically developing students who are learning to read in English compared to learning to read in a more transparent orthography (Ziegler & Goswami, 2005).

Dyslexia in Deep Orthographies

Dyslexia, by definition, is marked by the inability to read words accurately and/or fluently (International Dyslexia Association; IDA, 2002). This inability to decode and read words can limit the comprehension of what is being read, which makes individuals even less likely to read in the future (IDA, 2002). These issues typically stem from a deficit in the phonological component of language (IDA, 2002). Ziegler and Goswami (2005) reported that individuals with dyslexia share the phonological deficit regardless of their spoken language. In languages with a transparent orthography, dyslexia usually presents with struggles in word reading rate and deficient spelling while in deep orthographies, more emphasis is placed on the accuracy of word reading, whilst rate and spelling continue to be problematic (Ziegler & Goswami, 2005). This relationship between orthography and phonology has an impact on an individual's ability to read words accurately and fluently (Perfetti, 2007). Therefore, for individuals with dyslexia, who are likely to have a deficit in the phonological component of language, a more varied orthography exacerbates these deficits (Carioti et al., 2021; IDA, 2002). These individuals are unable to decode and make meaning of the words that they are trying to read. Ziegler and Goswami (2005) suggested that individuals with dyslexia reading in deep orthographies are more prone to issues with accuracy since there are more occasions to make errors while reading due to the inconsistency of the language. In English, readers with dyslexia have greater issues with reading accuracy since the variability of the letter-sound correspondence creates more opportunity to make errors while reading (Ziegler & Goswami, 2005). It is also noted that a more varied orthography exacerbates decoding deficits (Carioti et al., 2021).

Similar to Ziegler and Goswami's findings, Schmalz et al. (2015), found in a review, that when comparing the reading rate while decoding pseudo-words in languages with shallow versus deep orthographies, individuals who were reading in English were much slower than their shallow orthographic language counterparts. These findings show that phonological skills are impacted by the orthography of the language spoken and can be observed on both reading accuracy and reading rate measures (Georgiou et al., 2008).

Daniels and Share (2018) noted that there are other features that impact how the complexity of a language is defined besides the variability of the letter-sound correspondence of the orthography, including the impact of dialect and allography. In English, children are often exposed to different dialects between home and standard English that is taught in school and print. Examples include vernacular and southern dialects, which can lead to reduced reading performance (Johnson et al., 2017). Another feature that can pose a problem for developing readers in English is that each letter of the alphabet is represented by both as a capital and a lower-case letter. In their examples of allography, Daniels and Share (2018) noted that font type could also impede the acquisition of letter knowledge in English due to the variability of the letter form.

Dyslexia fonts have existed for nearly two decades and were designed to make it easier for readers with dyslexia to read. While it has been claimed that these specialized fonts mediate the effects of dyslexia, there is a lack of research that shows their effectiveness. The existing research on altered fonts shows mixed effects. Therefore, the purpose of this study is to add to existing research by measuring the effects of altered fonts compared to standard fonts on reading accuracy, reading rate, and reading comprehension for students with and without decoding difficulties. By reading word lists and passages printed in five different font types: TNR, TNR with added spacing, Arial, Arial with added spacing, and OpenDyslexic font, the study attempted to parse out the potential effects of the font characteristics to determine if the individual font characteristics affect the individual's reading ability.

While claiming to mediate the effects of dyslexia, some of these fonts cost money, even though research has shown varied effects. Common characteristics of dyslexia fonts are a San Serif font type, uniquely shaped letters, heavier markings at the bottom of the letters, and added spacing. In a meta-analysis of 13 studies, it was found that altered fonts had a small main effect on reading accuracy ($g = 0.18$, $p = 0.002$) but no effect on reading rate ($g = 0.11$, $p = 0.08$; Shewalter, 2023). However, when dyslexia status was included as a moderator, dyslexia fonts had an increased although small effect on the word reading accuracy of these individuals ($g = 0.24$). When language orthography was included as a moderator, dyslexia fonts had a larger effect in languages with deep orthography ($g = 0.43$). Moreover, the existing literature lacks the needed information to inform the adoption of these fonts (Shewalter et al., 2023). First, there are few studies completed in deep orthographies, such as English. This is relevant because dyslexia presents differently in deep and shallow orthographies. In shallow orthographies, dyslexia is characterized by slower rates of learning to read words, and individuals continue to have difficulty with reading fluency over time. However, in deep orthographies, readers with dyslexia present with pronounced struggles decoding words accurately due to the variability of the letter to sound correspondence (Carioti et al., 2021). In addition, very few studies examined how altered fonts impact reading comprehension. Therefore, the purpose of this study is to add to and extend the existing literature in determining if altered fonts benefit all levels of decoders' reading accuracy, rate, and comprehension in a deep orthographic language- English.

CHAPTER II: REVIEW OF LITERATURE

While some researchers have found that altered fonts show positive impacts on reading ability outcomes (e.g., Benmarrakchi & Kafi, 2021; Galliussi et al., 2020), other researchers found that altered fonts did not influence reading ability outcomes. (Duranovic et al., 2018; Kuster et al., 2018; Korinth et al., 2020). Experiments to evaluate the effects of dyslexia specific and altered fonts have been conducted with samples of individuals with dyslexia (e.g., Luniewska et al., 2021; Stagg & Kiss, 2021) and those with reading deficits (e.g., Powell & Trice, 2020; Zikl et al., 2015). Participants also included children (e.g., Bachmann & Mengheri, 2018; Hakvoort et al., 2017) and adults (e.g., Sjoblom et al., 2016; deLeeuw, 2010) with adequate word reading skills. This chapter will examine the role of altered fonts on reading accuracy, rate, comprehension, and preference of a specific font for different types of readers.

Meta-Analysis of Altered Fonts

In a meta-analysis of thirteen studies, reading accuracy was measured in eleven of the total studies (Shewalter et al., 2023). The results showed that for all sub-groups of individuals, those with reading disabilities, reading difficulty, and/or dyslexia and typically developing, altered fonts overall had a small main effect on reading accuracy ($g = 0.18$). Overall, studies showed that when individuals read text in altered fonts, they made fewer errors compared to reading text in standard fonts. Effect sizes ranged from $g = -0.30$ to $g = 1.33$ with an overall effect of $g = 0.18$. (Shewalter et al., 2023).

For reading rate, Shewalter et al. (2023) found that altered fonts overall had no effect ($g = 0.11$) with effect sizes ranging from $g = -0.35$ to $g = 0.78$. Across the studies included in the meta-analysis, most of the samples of individuals with dyslexia were small, averaging thirty participants, ranging from as low as twelve and as high as 75. In addition, only four of the thirteen studies reported in the meta-analysis were conducted in English. See Table 1 below for study characteristics.

Table 1

Study Characteristics of Shewalter et al. (2023) Font Meta-Analysis

Study	Sample Size	Dyslexia or RD	Mean Age of Dyslexic Sample	Language
Bachmann & Mengheri (2018)	54 24	RD D	9.58	Italian
Benmarrakchi & Kafi (2021)	12	D	10.5	Arabic
Duranovic et al. (2018)	23	D	10.77	Bosnian
Galliussi et al. (2020)	64	D	12.4	Italian
Hakvoort et al. (2017)	30	D	9.92	Dutch
Kuster et al. (2018)	85 85	D D	10.16[1]	Dutch
(de)Leeuw (2010)	21	D	21.5	Dutch
Luniewska et al. (2021)	38	D	12.17	Polish
Marinus et al. (2016)	39	RD	9.71	English
Powell & Trice (2020)	36	RD	10.34	English
Sjoblom et al. (2016)	24	D	22.58	English
Stagg & Kiss (2021)	32	D	13.5	English
Zikl et al. (2015)	75	RD	10.24	Czech

D = Dyslexia; RD = Reading Disability; [1] = Kuster et al. (2018) had two experiments; the mean age was averaged across the dyslexic samples.

It is worth noting that of the included studies in Shewalter et al. (2023) meta-analysis on altered fonts, only two of the 13 studies measured isolated word reading or reading of words in decontextualized word lists, despite dyslexia being a word level learning difference. Moreover, only three of the thirteen studies measured reading comprehension, although comprehension is the ultimate goal of reading.

Impact of Altered Fonts on Reading Accuracy

Relevant to this research, reading accuracy is one way that dyslexia specific and altered fonts can be measured to determine their benefit to individuals with reading difficulties. Without accurate reading, individuals will not be able to understand the text that they are reading. Reading accuracy can be measured by the number of correct words read or, inversely, by counting the number of errors made when reading.

Zorzi et al. (2012) compared reading accuracy outcomes across three groups of children: individuals with dyslexia who spoke Italian, individuals with dyslexia who spoke French, and an ability matched group of younger Italian speaking students. Although not as deep as English due to a simpler syllable structure, French is considered a deeper orthography than Italian (Seymour et al., 2003). The students read text that was written with normal spacing and text that was altered by increased spacing. The results showed that both groups of students with dyslexia read text with additional spacing with significantly fewer errors. Moreover, there were no differences between the groups with dyslexia (Zorzi et al., 2012). The ability matched group made very few errors to begin with resulting in a restricted range for improvement that limited the overall magnitude in the reduction they could experience.

Like Zorzi et al. (2012), Bertoni et al. (2019) altered spacing in their visual crowding experiments. The participants were Italian elementary students with dyslexia and an aged-matched group of average readers. The students read text printed on sheets of paper in TNR font in two spacing conditions. One condition was reduced spacing, and in the other, the spacing was increased within and between words relative to standard spacing. The results showed that the Italian students with dyslexia made more errors than their aged-matched peers in both conditions. When comparing the errors made by the students with dyslexia between the spacing conditions, they made fewer errors when the spacing was increased. In contrast, altered spacing did not impact the reading accuracy of the average readers. The researchers concluded that the reading accuracy difficulties of students with dyslexia can be compounded by visual crowding and that adjusting the spacing within and between words helps to attenuate these issues (Bertoni et al., 2019).

Wery and Diliberto (2017) conducted one of the few studies with an English-speaking sample. It was a single subject study that compared OpenDyslexic to two standard fonts, TNR and Arial, to determine if students were more accurate when reading words written in the dyslexia specific font. The subjects were twelve students in grades 3 to 6 who had a confirmed dyslexia diagnosis. Using an alternating treatment design, students read lists of words in one of the three font types, and accuracy was measured by the percentage of words read correctly. Each condition was repeated six times for a total of eighteen reading sessions. The results across the eighteen sessions hovered around 80% accuracy (Wery &Diliberto, 2017). OpenDyslexic did not impact reading accuracy relative to TNR or Arial. Likewise, there were no differences between the two standard fonts (Wery & Diliberto, 2017).

Overall, studies showed that the effects of altered fonts on reading accuracy were mixed. However, each of the studies measured different characteristics of the font. The current research will add to the body of literature by utilizing three different font types and comparing standard versions of the font to those with altered spacing.

Impact of Altered Fonts on Reading Rate

Another way to measure the effects of dyslexia specific and altered fonts is to measure reading rate. Reading rate can be measured directly through the measurement of words or syllables during a duration of time, such as minutes or seconds while individuals read text (e.g., word lists, narratives, expository text). The orthographic depth of the language can impact the rate at which individuals become fluent readers. Seymour et al. (2003) found that not only do individuals learning to read in a deeper orthographic language take longer to acquire reading skill, but they also have reduced reading rates due to the complexity of the language.

As previously noted, Zorzi et al. (2012) compared individuals with dyslexia across orthographies, one group who spoke Italian and the other French, to determine if increased spacing resulted in increased reading rate. The Italian and French participants each read text consisting of independent sentences unrelated to each other and written in both regular and text with added spacing (Zorzi et al., 2012). The text was identical apart from spacing, and the reading measures were given two weeks apart (Zorzi et al., 2012). The researchers reported that both groups benefited from added spacing and speculated that added spacing helps the reader identify the individual letters, a similar task across orthographies (Zorzi et al., 2012). However, the interpretation of these results is confounded by all participants having reread an identical text (Zorzi et al., 2012). Repeated readings could have resulted in an increased reading rate for the second reading of the text. In their 2017 meta-analysis on repeated reading with students with reading disabilities, Lee and Yoon found that even with a second reading, students showed increased fluency when reading passages again.

Zorzi et al. (2012) then compared the Italian participants with dyslexia to a group of younger, typically developing students who were matched on reading ability. The individuals with dyslexia read more syllables per second when reading text with added spacing compared to text without added spacing. The researchers proposed that the selective benefit of text with added spacing to the participants with dyslexia was likely due to the negative effects of visual crowding for individuals with dyslexia (Zorzi et al., 2012).

Martelli et al (2009) took a slightly different approach to explore font features on the readability of text for individuals with dyslexia. These researchers also studied the Italian language and compared four print sizes to find the critical print size for students with dyslexia and their typically developing peers. Critical print size was determined by measuring reading rate and operationalized as the print size at which the student demonstrates the greatest reading rate. Participants included Italian sixth grade students with dyslexia and their peers who did not have reading difficulties. Students read single words presented in the middle of a computer screen in the serif font, Courier, in the four print sizes. By increasing the font size, the spacing is also increased. The researchers found that the critical print size was much larger for students with dyslexia compared to their peers (Martelli et al., 2009). However, they noted that the students with dyslexia continued to read slower than their typically developing peers, even with altered print size (Martelli et al., 2009).

van den Boer and Hakvoort (2015) used a similar methodology as Zorzi et al. (2012), but they explored the effect of spacing in Dutch which has a shallow orthography. Their sample included Dutch children in grades 2 and 4 who read words in which print spacing ranged from decreased inter-letter spacing, normal spacing, and four levels of increased inter-letter spacing. The children read lists of words that were either single syllable or words with two syllables for a total of twelve conditions. The sample's reaction times were measured and transferred to a reading rate score of words per second.

Contrary to Zorzi et al.'s (2012) findings, van den Boer and Hakvoort (2015) found that additional spacing did not prove to be effective for either typically developing students or those with reading difficulties. Neither the full sample nor the students with reading difficulties showed an increased reading rate for words with larger inter-letter spacing than normal spacing (van den Boer & Hakvoort, 2015). However, when the reduced spacing condition was compared to the normal spacing, researchers found that reading rate was decreased in both groups (van den Boer & Hakvoort, 2015). The researchers speculated that results could be different under different reading conditions (i.e., passage rather than word reading) since reading text passages would provide a greater opportunity for crowding.

Perea et al. (2012) compared font with increased inter-letter spacing to normally spaced font to determine if increased spacing improved reading rate in Spanish. The authors noted that Spanish is a shallow orthography like Italian and Dutch. The sample consisted of adult typical readers, typically developing children in grades 2 and 4, and children with confirmed dyslexia who were from Spain and spoke Spanish as their primary language. The participants read lists of words and short stories presented on a computer screen in two spacing conditions: standard text spacing and text with added spacing. The results showed that participants in all groups had shorter reaction times when reading spaced font as opposed to the normally spaced font, and the effect was even greater for children with dyslexia (Perea et al., 2012).

Ismail and Jaafar (2018) compared five levels of font size using Arial font with sizes that ranged from 12 to 28-points type-written in a Malaysian language which could be classified as a deep orthographic language due to its irregularities. The sample included students with confirmed dyslexia and a control group that did not have reading difficulties. The participants read text presented on a computer screen in various font sizes while researchers measured the time it took for the participant to read the text aloud. The results showed that all participants, regardless of group membership, had decreased reading times as the font size was increased (Ismail & Jaafar, 2018).

Joo et al. (2018) included English speaking college students and children who reported having reading difficulties or dyslexia for a visual crowding experiment. Using measures of reading rate, participants read words written with typical spacing and increased spacing within and between words. They found that only the individuals with the lowest reading ability benefited from additional spacing. The authors concluded that the adult sample had likely developed compensation skills to overcome their previous reading deficits. The researchers suggested that it was only a sub-group of individuals with reading disabilities that are affected by visual crowding benefit from added spacing to text.

Similar to the studies that reported the effects of altered fonts on reading accuracy, studies that measured reading rate also showed mixed results. Most of the studies utilized increased spacing and size rather than comparing various font types. The current study will add to the current literature by including both spacing and different font types.

Impact of Altered Fonts on Eye Tracking Measures

Reading rate can also be measured indirectly through eye tracking procedures. Eye tracking records the number of fixations of the eye during a reading task and can be reported per minute, second, or for the duration of the specific reading task (Masulli et al. 2018). Korinth et al. (2020) evaluated increased spacing to determine if skilled German readers would show increased reading ability when reading text with added spacing. German, like English, has a complex syllable structure, but the orthography remains shallow compared to English (Seymour et al., 2003). Using eye tracking procedures, they found that typical readers without reading deficits read lists of words faster with added spacing between the letters but read text passages slower with added inter-letter spacing (Korinth et al., 2020). The researchers speculated that the benefit of added spacing within text might be unique to individuals with reading difficulties. However, they did not include individuals with reading difficulties in their sample to test this hypothesis.

Bellocchi et al. (2019), also using eye tracking procedures, found similar results when words were presented in both standard and added spacing. The participants were French speaking elementary students who did not demonstrate any deficits in reading ability. The students read single words that were presented on a computer screen and each of the words consisted of either 5 or 9 letters. The authors noted that the difference in the total letters of the words, five letters for added spacing versus nine letters for words in standard spacing type, was to control the width of the words presented on the screen. Hence, the words with five letters allowed spacing to be added without creating a larger display than the words with nine letters. The delay of eye movements between points of fixation was notably longer when students read the five letter words with greater spacing indicating that inter-letter spacing did not improve students' reading rates.

Similarly, Masulli et al. (2018) used eye tracking to measure eye movement and fixations while three groups of children read text written in normally spaced font, font with increased spacing, and font with increased size and spacing. The groups consisted of French children with dyslexia and two groups of their typically developing peers, one matched by age and the other matched by reading ability (Masulli et al., 2018). They found that while increased font size and additional spacing resulted in shorter duration of fixations during reading, the children had increased number of eye movements which caused no difference in the amount of time necessary for reading (Masulli et al., 2018). The researchers proposed that eye movements during reading are affected by both the size and spacing of the text, and these effects exist regardless of reading disability or dyslexia (Masulli et al., 2018). However, the researchers noted that eye tracking data could show different patterns in languages with deep orthographies (Masulli et al., 2018).

In another study, Rello et al. (2013) compared various font sizes using a sample of Spanish speaking individuals with confirmed dyslexia who were mostly high school or college students. The font sizes ranged from 10 to 26-point using an unspecified sans serif font type and four levels of spacing. Their results were obtained through eye tracking procedures while participants read from a computer web page. The results indicated that eye fixation continued to decrease as the font was enlarged from 10-point font up to 18-point font (Rello et al., 2013). The authors noted that eye fixations were not reduced past 18-point font size (Rello et al., 2013). However, Martelli et al. (2009) highlighted that increasing the font size would also increase the space between the letters, confounding increased font size with the spacing between letters. In addition, Rello et al. (2016) cautioned that eye fixation does not directly measure the time taken to read the text.

Rello & Baez-Yates (2013) attempted to parse out the effects of specific characteristics of various fonts. Although variations of spacing were not included in their analysis, the researchers utilized italic print with three of the fonts. There was a total of twelve fonts which included OpenDyslexic (dyslexia specific font), TNR (font with serifs), Arial (sans serif font), and the italics versions of these three. All participants had a confirmed diagnosis of dyslexia, spoke Spanish, and their ages ranged from eleven through adult (Rello & Baez-Yates, 2013). The sample read paragraphs from a book that were divided into passages with an equal number of words. Eye tracking procedures were used as the participants read silently. The results showed that text printed in Arial font was read during the shortest amount of time while Arial italics took the greatest amount of time (Rello & Baez-Yates, 2013). OpenDyslexic showed comparable results, coming in at a close second to Arial font, but interestingly, the authors noted that OpenDyslexic font in both the original and italic versions were the least preferred font presented within their study (Rello & Baez-Yates, 2013). When analyzing the effects of serifs on reading time, the researchers report that the results showed no differences between the font types (Rello & Baez-Yates, 2013).

Reading Comprehension

Reading comprehension is the least reported outcome measure of previous research on the effects of dyslexia specific and altered fonts, as only three out of 13 studies included it as an outcome (Shewalter et al., 2023). Although reading comprehension measures have been used as control measures in eye tracking studies to ensure that participants are reading for content and not just skimming the page, the results are often not reported (Rello & Baeza-Yates, 2013; Rello et al., 2016).

French et al. (2013) compared serif and sans serif fonts to determine if English speaking students were better able to recall information from what was read. The sample consisted of high school students who silently read text written in either Arial or Monotype Corsiva, a "disfluent font" with serifs, and then answered multiple choice questions about what they had read (French et al., 2013, p. 302). When analyzing the full sample, the researchers found that comprehension increased by over 12 percent in correct responses when students read text written in the font with serifs versus the sans serif font, Arial (French et al., 2013). When only the individuals with dyslexia were included in the analysis, students showed an increase of 19 percent in comprehension scores when reading the text written in Monotype Corsiva versus Arial (French et al., 2013). The authors speculated that when the students were reading text written with a serif font, they utilized more cognitive resources which enhanced their retention and comprehension skills (French et al., 2013). However, this theory could be debated since the widely accepted notion is that freeing up cognitive resources leads to better comprehension of text rather than increasing cognitive load (Kendeou et al., 2014).

Rello et al. (2013) compared reading comprehension scores for font sizes which ranged from 10 to 26-point using an unspecified sans serif font type and four levels of spacing. Spanish speaking participants with a confirmed diagnosis of dyslexia read multiple choice comprehension questions that were both text and inference-based and the results were reported by percent correct. The results indicated that comprehension was the greatest when participants read text written in 18-point font while text written in greater than 18-point, the scores declined (Rello et al., 2013). Reading comprehension scores were the lowest when participants read text written in 10-point font (Rello et al., 2013).

In another study, Spanish speaking fourth grade students consisting of a group with confirmed dyslexia and a group of typically developing students read text written in TNR font and TNR with added spacing then answered five open-ended comprehension questions (Perea et al., 2012). Although typically developing students did not show improvement with the added spacing, the sample of students with dyslexia increased their comprehension scores by ten percent (Perea et al., 2012). The authors noted that although the increased spacing did not prove to be effective for the typically developing group, neither was it disadvantageous, which the authors suggested that texts can be altered to benefit all groups of students (Perea et al., 2012).

Powell and Trice (2020) examined the difference between reading comprehension scores when students read text written in three different fonts (i.e., TNR, Arial, and Dyslexie). The participants were English speaking students in grades 4 and 5 who had an identified reading disability. After the students read the text, they answered three text-based comprehension questions. The results were not statistically different between any of the three fonts (Powell &Trice, 2020).

Similar to Powell and Trice (2020), Benmarrakchi and Kafi (2021) also compared different fonts to determine if the font type impacted reading comprehension scores. The participants were children and young adults aged 8 to 26 years and speakers of Arabic who formed three groups: children with confirmed dyslexia based on the students' clinical test results from a dyslexia center, a typically developing age-matched group, and adult participants served as a skilled readers group. Each participant read text that was written in the dyslexia specific font, Arabolexia, and a standard Arabic font then responded orally to three text-based comprehension questions. The researchers reported that the results were not statistically significant for any of the three groups (Benmarrakchi & Kafi, 2021).

Rather than font type, Luniewska et al. (2021) altered spacing with a single font by adding or reducing the inter-letter spacing. The participants were Polish students aged 10 to 14 years with a dyslexia diagnosis and a group of their typically developing peers. Students read a total of ninety-three sentences that were divided between three reading conditions: TNR with standard spacing, TNR with condensed spacing, and TNR with added inter-letter spacing. Each of the sentences averaged ten words per sentence. The students read half of the sentences silently and the other half were read aloud. After reading each sentence, the student was presented with a set of four pictures and had to select the picture that corresponded with the sentence. Like the other studies, Luniewska et al. (2021) reported that the results were not statistically significant for either group or condition. The authors also reported that neither reading silently nor aloud impacted these results (Luniewska et al., 2021).

Student Preference

While not as objective as the results exploring improved accuracy or rate of reading, individual preferences towards the perceived readability of font could support reader engagement and time on task. Students today have greater access to computers and internet. Computers provide hundreds of font types and students are only limited by preference and personal requirements such as assignment criteria. Adults are only limited by professional expectations of font type and presentation of typed works. Along with the hundreds of font types, individuals can choose to personalize their font type by adding boldness to letters, italics font style, and adjusting font size and spacing. As individuals are reading previously typed text, they can zoom in and out to increase or decrease the size of the text and often can change how the text is displayed. Following the three reading outcome measures, a measure was given to address the students' perception of the font types and if they preferred the dyslexia specific font type or altered fonts over the standard font type.

Previous literature on dyslexia specific and altered fonts found that reading text in a preferred altered font did not necessarily lead to increased readability (Kuster et al., 2018). The participants included Dutch speaking children aged 7-12 years who read text in Dyslexie font, TNR, and Arial. The researchers reported that while most of the students preferred Arial and TNR over Dyslexie, there were also a portion of the students who did not have a preference, however, no difference was found between the fonts for reading accuracy or rate (Kuster et al., 2018).

Another study, however, found that students did have preferences. Benmarrakchi and Kafi (2021) compared Arabolexia to a standard Arabic font. The participants included elementary aged students with dyslexia, a group of their typically developing peers, and a group of adult skilled readers. The elementary students with dyslexia made fewer errors with dyslexia specific font compared to the standard font. Most of the students with dyslexia liked the font and wanted to use it. In contrast, although their typically developing counterparts said that they liked the font, they reported that they would not use it on their own since they found it to be different (Benmarrakchi & Kafi, 2021). The skilled reader group neither liked the font nor would prefer to use it if given the opportunity (Benmarrakchi & Kafi, 2021).

Gaps in the Literature on Dyslexia and Altered Font

The existing literature on dyslexia specific and altered fonts contains several gaps. First, there are currently very few studies that have been conducted in deep orthographies such as English which is relevant because dyslexia presents differently in deep and shallow orthographies regarding reading accuracy and reading rate (Carioti et al., 2021). The reading measure outcomes used within the existing literature vary considerably and compare a wide variety of font characteristics. Font is manipulated by spacing, size, and boldness. Font types are also compared including dyslexia specific, standard fonts, and altered versions of standard fonts. It is difficult to determine if one characteristic is beneficial for struggling readers. The identification of the participants is another area of concern.

Study Purpose

Looking at the measures utilized in previous research, most outcome measures included reading rate and even fewer measured reading accuracy. During a closer examination of the studies reported in a meta-analysis on dyslexia specific and altered font, only two of the studies explored the effect of font on isolated word reading, and only three of the studies measured for reading comprehension (Shewalter et al., 2023). The current study will add to existing literature by including a reading comprehension measure to determine if dyslexia specific and altered fonts improve comprehension for students with varying levels of decoding ability. Reading accuracy and rate were also measured using isolated words from decontextualized word lists and narrative passages.

Many of the font characteristics in previous literature are different. Some used fonts with serifs, others used sans serif font, while even others compared spacing. This is a limitation and gap in this area of research since all studies are comparing different characteristics of the font. The current study intends to parse out those characteristics to evaluate 1. serif and sans serif fonts, 2. standard spacing and increased spacing, and 3. the distinctiveness of the letters in the dyslexia-specific font. By parsing out the font features, the study was seeking to determine if a specific font characteristic impacts decoders' reading accuracy, reading rate, and/or reading comprehension.

The current study sought to investigate the effect of OpenDyslexic font on reading accuracy, rate, and comprehension compared to the standard fonts TNR and Arial with and without serifs and with added spacing and in default spacing settings in individuals with decoding deficits and typical readers. This information would be beneficial because if altered fonts improve the reading ability of individuals with decoding deficits, printing text using this font could be a quick and low-cost accommodation to allow those individuals immediate access to text. This could also change the way books are published.

One goal of this research was to expand from the results of the meta-analysis on dyslexia specific and altered fonts. This meta-analysis showed that there was limited research conducted in deep orthographies such as English. Following these three outcome measures of reading, another question was asked about the students' perception of the dyslexia specific and altered fonts.

The goal of the current study is to answer the following research questions:

1. Do altered fonts impact students' reading rate, accuracy, and comprehension, and if so, which specific font features (i.e., serif vs. sans serif, normal spacing vs. added spacing, dyslexia-specific font vs. others) facilitate increased reading rate, accuracy, and comprehension?
2. Do altered fonts differentially benefit students with decoding weaknesses on reading rate, accuracy, comprehension compared to students without decoding difficulties?
3. What are students' perceptions of the various font types?

CHAPTER III: METHODOLOGY

Participants

A priori power analysis was completed using GPower to determine the sample size needed to show effects similar to the Shewalter et al. 2023 meta-analysis. The results indicated a sample greater than 1000 per group (i.e., students with decoding difficulties and students without decoding difficulties). Since a sample of 2000 or more students is not likely attainable, previous literature was reviewed for sample size. The dyslexia subgroups of the meta-analysis had a mean sample size of 42 and ranged from 12 to 85 participants. Recruitment was in a public elementary K-8 school in Tennessee. The sample included students who speak English as a first language from grades 3, 4, and 5 ranging from 8 to 11 years of age. Students who did not speak English as a first language were excluded because students who speak a language other than English as their first language may not be assessed properly using decoding and fluency assessments written in English.

Given parent permission and agreed student assent, students were screened to determine group placement (i.e., students with decoding difficulties and students without decoding difficulties). Consistent with previous literature and the school district's current Response to Intervention (RTI) criteria for the identification of students needing intervention, the cut-off score of 25% was used to group students by their ability to decode words (Spencer et al., 2014). Students who score at or below the 25th percentile on the Test of Word Reading Efficiency-Second Edition were identified as students with decoding difficulties, and those scoring above the 25th percentile were identified as students without decoding difficulties. While disability identification is not straightforward as reading disability happens on a continuum, by identifying students using screening measures including word reading and decoding and utilizing a 25% cut-off score, the chance of misidentifying the student is reduced (Compton et al., 2010). Demographic data that was collected includes gender, age, grade, and if the student received additional reading instruction (e.g., special education services or RTI).

Measures

Test of Word Reading Efficiency- Second Edition (TOWRE-2). The Test of Word Reading Efficiency-Second Edition (TOWRE-2; Torgesen et al., 2012) was used as a screening measure. This measure consists of two subtests which include Sight Word Efficiency (SWE) and Phonetic Decoding Efficiency (PDE). Each of the subtests is timed and the full test can be completed in 5 to 10 minutes. The SWE subtest measures how accurately and fluently the student can read real words while the PDE subtest measures pseudo-word reading skill. Subtest A was used in this study. Alternate form reliability exceeds .90. The scores of the two sub-tests are compiled for a Total Word Reading Efficiency score. The TOWRE-2 provides normed reference scores for individuals aged 6 to 24 years of age. Normed scores include age equivalency, grade equivalency, percentiles, and standard scores. Index scores have a mean of one hundred with a standard deviation of fifteen.

Dynamic Indicators of Basic Early Literacy Skills- 8th Edition (DIBELS)- Oral Reading Fluency Progress Monitoring (ORF-PM). DIBELS- 8TH Edition Oral Reading Fluency Progress Monitoring (ORF-PM) passages were used to measure reading accuracy and rate. DIBELS ORF-PM is a standardized measure for grades 1 to 8. The ORF-PM passages are grade leveled passages based on Fletch-Kincaid grade level scores. Each of the passages is presented in TNR font which is standard and locked for editing. Given permission and access from the University of Oregon, the passages were altered by adjusting the font to the five font types of this research. DIBELS ORF-PM consists of twenty total passages for each grade level that consist of both narrative and expository text and vary in length from about 150 to 400 words for grades 3 to 5. Reliability for DIBELS ORF-PM is .94 for the grade 3 oral reading fluency passages. Typical DIBELS ORF-PM administration is quick, taking one minute where students read as much as they can during that time. For this research, only narrative passages were used to control for genre, and the text length was kept as consistent as possible across passages (i.e., the number of words were not changed from the original DIBELS passages only the font type). Therefore, the total of five passages were chosen at the third-grade level to allow access for all grade level students. Each of the passages consist of at least two hundred words, are comparable in the number of words, and are narrative text to control for genre. For reading rate, the student read the text in its entirety and the score was calculated as the number of words per minute. Reading accuracy was recorded by the number of errors that students made while reading. The administration guidelines for recording errors remained unchanged (i.e., any words that are skipped, read incorrectly, or do not respond after 3 seconds were counted as errors). Self-corrections and repetitions were not counted as errors. See Table 2 below for passage readability.

Table 2

DIBELS Passage Readability

Passage	Flesch-Kincaid Grade Level	Lexile Level	Number of Words in Passage
TNR	3.4	5-600	217
Arial	3.5	6-700	212
TNR spaced	3.8	6-700	216
Arial spaced	3.3	4-500	223
OpenDyslexic	3.8	6-700	209

(DIBLES- Administration and Scoring Guide p. 107).

Researcher Created Comprehension Measure. The Researcher Created Comprehension Measure contains literal text-based questions developed from the DIBELS ORF-PM measures. For each of the five passages, five comprehension questions were created to answer “who”, “what”, “when”, “where”, “why”, and “how” type questions where the answers were explicitly stated within the text (see Appendix), and the answer was selected from four multiple-choice answers (i.e., A, B, C, and D). After the students read the corresponding ORF-PM measure, the students were provided with a paper copy of the comprehension questions, which was read aloud. The students had the option of responding on their paper or providing their answers orally. The students did not have access to the passage during the administration of this measure. This comprehension measure was not timed. If the student does not know how to answer the question, the researcher provided the prompt, “think back to what you have read.” If the student still did not provide a response, the researcher said, “let’s try the next one.” (See Appendix A).

Researcher Created Word Reading Measure. The Researcher Created Word Reading Measure was adapted from the Assessment of Encoding and Decoding Progress Test (ADEPT: Sawyer, 1998, 2001). This measure consisted of 50 real words that are displayed in two columns for each font type- TNR, Arial, TNR with added spacing, Arial with added spacing, and Open Dyslexic for a total of five word reading lists. Each word was limited to one syllable and consisted of three to six letters. The words utilized common spelling patterns including short vowels, vowel digraphs, vowel-consonant-E, R-controlled vowels, and Y as a vowel. The words of each subpart were changed by adjusting a letter or letter combination across the five font types (e.g., rat, sat, hat, hit, hut). The vowel spelling patterns were another adjustment across the five font types (e.g., shone and loan). Students were instructed to read the first column and then the second column as they are timed for 30 seconds. Accuracy was scored as the number of errors and rate was scored as the number of words read correctly in 30 seconds. If students read all 50 words during the 30 seconds, they were instructed to begin repeating the words in the first column (see Appendix B).

Researcher Created Non-Word Reading Measure. The Researcher Created Non-Word Reading Measure like the Word Reading Measure was adapted from ADEPT (Sawyer, 1998, 2001). This measure consisted of 50 non-words that were displayed in two columns for each font type- TNR, Arial, TNR with added spacing, Arial with added spacing, and Open Dyslexic for a total of five word reading lists. Each non-word was limited to one syllable and consisted of three to six letters. The words utilized common spelling patterns including short vowels, vowel digraphs, vowel-consonant-E, R-controlled vowels, and Y as a vowel. The words of each subpart were changed by adjusting a letter or letter combination across the five font types (e.g., gat, lat, dat, dit, and dut). The vowel spelling patterns were another adjustment across the five font types (e.g., plobe and troat). Students were instructed to read the first column and then the second column as they are timed for 30 seconds. Accuracy was scored as the number of errors and rate was scored as the number of words read correctly in 30 seconds. If students read all 50 non-words during the 30 seconds, they were instructed to begin repeating the words in the first column (see Appendix B).

Researcher Created Preference Assessment. The Researcher Created Preference Assessment entailed the student placing the numbers 1 through 5 printed on cardstock paper on five example paragraphs that differ only by font type. “5” signified the font type that the student preferred the most and “1” for the font that the student preferred the least. The text examples were not required to be read. Students used the example to respond to the task of labeling each font type in the order of their preference. For the final question of the assessment, the student was asked why they chose the paragraphs that were labeled with the numbers “1” and “5”. This measure was not timed (see Appendix C).

Procedures

The researcher was offered a verbal invitation to complete the study at a local elementary school and relevant administrators had agreed upon the dissertation timeline. The director of schools provided an email confirmation of this approval. Once agreement from the dissertation committee was obtained, an official letter stating agreement for the researcher to conduct the study contingent on IRB approval was sent. The researcher then sought IRB approval to begin the study. After IRB approval (#IRB-FY2024-168), parent/guardian permission forms went home with each student in grades 3, 4, and 5. The researcher made themselves available to answer questions about the research during the school day. Upon receipt of the signed permission from parents agreeing that the student is eligible to be part of the study, students were provided with a child assent which was simplified due to the age of the child (age 8 to 11 years of age). The assent was provided in writing and read aloud for all students. Screening began for group placement as soon as permission was obtained.

Screening was completed for all students to determine each student’s word reading level. Testing took place over one to two sessions. Each session was a maximum of 45 minutes in length. During the first session, students completed the screening measure (i.e., TOWRE-2) and two passages from the DIBELS-ORF-PM along with their corresponding Researcher Created Comprehension Measures. Next, based on the remaining time, the student completed the Researcher Created Word Reading Measure, then the Researcher Created Non-Word Reading Measure, and the Researcher Created Preference Assessment. Finally, the remaining three passages with the corresponding Researcher Created Comprehension Measures. Each of the measures were counterbalanced across students (i.e., ABCDE; BCDEA; CDEAB; DEABC; EABCD; etc.) to minimize any effects of the order of presentation. The need for a second session depended upon individual student reading rates. Three students were absent for the second session and did not complete all five passages.

Students were taken to a quiet room where the researcher confirmed student assent and explained that the students would be reading sets of real words and made-up words. Once data was collected for the screening measures, two groups (i.e., students with decoding difficulties and students without decoding difficulties) were established using a cut-off score of 25th percentile on the TOWRE-2 timed decoding and sight word subtests. Those students scoring at or below the 25th percentile on the decoding and sight word reading measures were identified as "students with decoding difficulties" and those students scoring above the 25th percentile were identified as "students without decoding difficulties".

After screening was completed, the students then read a series of five passages modified for research purposes from the DIBELS ORF-PM passages with permission granted from Oregon University legal department to alter the passages. Each of the five different passages were reprinted using five different font types with TNR and Arial matched in size to OpenDyslexic font: TNR unaltered, TNR with added spacing, Arial unaltered, Arial with added spacing, and OpenDyslexic font.

Students read aloud from the printed version of each of the five passages at the third-grade level to allow access to all grade levels while keeping the passages consistent across all participants. The printed passage was placed on the table in front of the student and the student read aloud as the researcher both audio recorded and timed the reading for reading accuracy and reading rate. The researcher noted errors made during reading on a separate printed passage sheet. One sheet for data collection was used for each passage for each student. The audio recording was used to ensure that data was collected effectively. At the end, after reading each of the passages, the student answered five multiple choice comprehension questions presented on paper and orally by the researcher. The comprehension questions were printed on a separate page and the student did not have access to the passage. The questions were read aloud for each student to eliminate possible decoding deficits affecting comprehension ability. Students provided their answers on the student copy of the comprehension questions where they circled the correct choice (i.e., A, B, C, or D). After the passages and comprehension questions, the word and non-word reading measures were given. The preference assessment was administered at the end of the first testing session. The reading and answers to all assessments were both audio recorded and documented by the researcher. At the end, when the student had answered the last question, the researcher said, “Thank you for your hard work!” The student was offered a choice from the treasure chest as a reward for their hard work. The researcher returned the student to class and screening/testing began with the next eligible student.

After data collection was completed, the researcher recorded the data into a data management system. A second researcher reviewed the recordings of the reading measures to calculate inter-observer agreement for researcher errors which was recorded at 98%. For anything less than 100%, the two researchers evaluated the discrepancies to determine the problem, and changes were made to correct the data. The students’ reading rate was reported as words per minute (wpm) and reading accuracy was reported as number of errors. Reading comprehension was reported as a percentage of correct answers. Word/non-word reading were reported as the number correct for reading rate and number of errors for reading accuracy. The

Preference Assessment score used the ratings (i.e., 1 to 5) to calculate a sum of the ratings across each of the font types.

CHAPTER IV: RESULTS

This study implemented a within-subject quasi-experimental design to investigate the effects of altered fonts compared to standard fonts on reading rate, reading accuracy, and reading comprehension for students with and without decoding deficits. The research addressed the following questions: 1. Do altered fonts impact students' reading rate, accuracy, and comprehension, and if so, which specific font features (i.e., serif vs. sans serif, normal spacing vs. added spacing, dyslexia-specific font vs. others) facilitate increased reading rate, accuracy, and comprehension? 2. Do altered fonts differentially benefit students with decoding weaknesses on reading rate, accuracy, comprehension compared to students without decoding difficulties? 3. What are students' perceptions of the various font types? Demographic and descriptive data are provided below in Table 3.

Table 3

Descriptives

	Decoding Difficulties		Without Decoding Difficulties		Overall	
Characteristic	*n*	*M*	*n*	*M*	*n*	*M*
Age	24	10.06	31	10.05	55	10.06
Male	14		12		26	
Female	10		19		29	
Grade						
3rd	11		12		23	
4th	6		13		19	
5th	7		6		13	
Screening TOWRE	*M*	*SD*	*M*	*SD*	*M*	*SD*
Scaled Score	80.92	7.83	100.10	6.73	91.73	11.98
Percentile Rank	12.54	6.86	49.77	16.25	33.53	22.67

Note: All 55 students were given the screening measure.

Impact of Altered Fonts

First, repeated measures Analysis of Variance (ANOVA) using a within subject design was used to evaluate font type on reading rate, accuracy, and comprehension across the measures. Bonferroni correction was used to control familywise error (Field, 2013). Means and standard deviations are reported in Tables 4 and 5.

Table 4

Passage Means and Standard Deviations for Rate, Accuracy, and Comprehension

	Decoding Difficulties (*n* = 23)			Without Decoding Difficulties (*n* = 29)			Overall (*n* = 52)	
Rate	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	95.91	32.26	103	139.24	30.56	118	120.08	37.86
Arial	90.78	33.85	114	132.45	32.49	115	114.02	38.86
TNR spaced	92.39	33.24	112	129.86	29.76	112	113.29	36.28
Arial spaced	121.09	36.34	138	162.21	33.11	117	144.02	39.96
OpenDyslexic	92.87	29.64	102	130.55	32.96	122	113.88	36.50
Accuracy	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	9.43	7.57	23	3.21	3.04	13	5.96	6.29
Arial	12.30	9.97	35	3.10	2.55	10	7.17	8.23
TNR spaced	12.17	11.90	41	3.28	2.96	23	7.21	9.26
Arial spaced	4.74	4.35	13	1.24	1.43	6	2.79	3.52
OpenDyslexic	12.43	13.22	54	3.90	2.64	11	7.67	9.88
Comprehension	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	81.74	19.92	60	86.21	15.22	40	84.23	17.42
Arial	80.87	20.43	60	85.52	15.94	40	83.46	18.03
TNR spaced	88.70	15.76	60	95.86	8.25	20	92.69	12.54
Arial spaced	86.96	15.50	40	94.48	9.10	20	91.15	12.78
OpenDyslexic	91.30	14.56	60	92.41	11.23	40	91.92	12.69

Note: 3 students were absent for the 2nd session and did not complete all 5 passages.

Table 5

Word and Non-Word Reading Means and Standard Deviations for Rate and Accuracy

	Decoding Difficulties (*n* = 24)			Without Decoding Difficulties (*n* = 31)			Overall (*n* = 55)	
Word Rate	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	27.25	9.67	33	42.10	8.68	34	35.62	11.70
Arial	25.13	9.20	30	41.61	8.27	32	34.42	11.92
TNR spaced	26.13	10.25	33	42.16	8.46	32	35.16	12.21
Arial spaced	25.04	9.05	31	39.68	8.85	35	33.29	11.49
OpenDyslexic	24.13	8.68	29	41.13	8.17	32	33.71	11.90
Accuracy	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	3.17	2.94	11	1.00	1.21	5	1.95	2.38
Arial	4.13	3.11	12	0.68	1.28	5	2.18	2.83
TNR spaced	3.50	2.96	9	1.10	1.62	7	2.15	2.58
Arial spaced	3.50	3.27	13	1.74	1.88	8	2.51	2.70
OpenDyslexic	4.21	3.39	14	1.23	1.61	6	2.53	2.92
Non-Word Rate	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	11.50	6.04	25	24.42	8.14	32	18.78	9.70
Arial	11.92	6.17	26	27.29	6.95	25	20.58	10.11
TNR spaced	12.04	7.21	27	26.19	7.79	32	20.02	10.30
Arial spaced	13.75	6.49	27	26.74	8.44	39	21.07	9.99
OpenDyslexic	12.54	6.88	27	26.13	7.87	30	20.20	10.04
Accuracy	*M*	*SD*	*R*	*M*	*SD*	*R*	*M*	*SD*
TNR	6.13	4.56	16	3.77	3.34	13	4.80	4.06
Arial	5.67	5.19	21	3.52	3.48	14	4.45	4.40
TNR spaced	5.63	4.63	16	3.45	2.87	11	4.40	3.86
Arial spaced	4.50	4.01	16	2.68	2.18	8	3.47	3.21
OpenDyslexic	5.67	4.62	17	3.55	2.73	9	4.47	3.79

Mauchly's Test of Sphericity was used to determine if the data met the assumption of sphericity. For reading rate at the passage level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 14.80, p = .097. The effect of font type on reading rate was significant at the .05 level, $F(4, 204) = 131.56$, $p < .001$.

For reading accuracy at the passage level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated x^2 (9) = 63.31, $p < .001$, so the degrees of freedom were corrected using Lower-bound. The effect of font type on reading accuracy at the passage level was significant, $F(1, 51) = 14.33$, $p < .001$.

For reading rate at the word level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 11.77, p = .227. The effect of font type on reading rate was significant, $F(4, 216) = 5.24$, $p < .001$. For reading accuracy at the word level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated x^2 (9) = 20.35, p = .016, so the degrees of freedom were corrected using Lower-bound. The effect of font type on reading accuracy was not statistically significant, $F(1, 54) = 1.58$, p = .214.

For reading rate on the non-word reading measure, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 4.96, p = .838. The effect of font type on reading rate was significant, $F(4, 216) = 4.39$, p = .002. For reading accuracy, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 11.94, p = .217. The effect of font type on reading accuracy was significant, $F(4, 216) = 2.75$, p = .029.

For Reading Comprehension, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated x^2 (9) = 27.03, p = .001, so the degrees of freedom were corrected using Lower-bound. The effect of font type on reading rate was significant, $F(1, 51) = 5.80$, $p = .02$.

Effect of Font Features on Reading Rate

Serif versus Sans Serif. To determine if font characteristics impacted reading rate, paired samples *t*-tests were used. See Table 6 below.

Table 6

Overall Effect Size

Contrast	1		2				
Passage- Rate	*M*	*SD*	*M*	*SD*	*t*(51)	*p*	Cohen's *d*
TNR vs. Arial	120.08	37.86	114.02	38.86	4.42	< .001	0.16
TNR vs. TNR spaced	120.08	37.86	113.29	36.28	4.32	< .001	0.18
Arial vs. Arial spaced	114.02	38.86	144.02	39.96	-15.42	< .001	-0.76
OpenDyslexic vs. TNR	113.88	36.50	120.08	37.86	-4.47	< .001	-0.17
OpenDyslexic vs. Arial	113.88	36.50	114.02	38.86	-0.10	.92	-0.004
OpenDyslexic vs. TNR-S	113.88	36.50	113.29	36.28	0.41	.69	0.02
OpenDyslexic vs. Arial-S	113.88	36.50	144.02	39.96	-16.46	< .001	-0.79
Word Reading- Rate	*M*	*SD*	*M*	*SD*	*t*(54)	*p*	Cohen's *d*
TNR vs. Arial	35.62	11.70	34.42	11.92	2.38	.02	0.10
TNR vs. TNR spaced	35.62	11.70	35.16	12.21	0.66	.51	0.04
Arial vs. Arial spaced	34.42	11.92	33.29	11.49	1.92	.06	0.10
OpenDyslexic vs. TNR	33.71	11.90	35.62	11.70	-3.07	.003	-0.16
OpenDyslexic vs. Arial	33.71	11.90	34.42	11.92	-1.31	.20	-0.06
OpenDyslexic vs. TNR-S	33.71	11.90	35.16	12.21	-2.37	.02	-0.12
OpenDyslexic vs. Arial-S	33.71	11.90	33.29	11.49	0.80	.43	0.04
Non-Word- Rate	*M*	*SD*	*M*	*SD*	*t*(54)	*p*	Cohen's *d*
TNR vs. Arial	18.78	9.70	20.58	10.11	-2.95	.005	-0.18
TNR vs. TNR spaced	18.78	9.70	20.02	10.30	-2.09	.04	-0.12
Arial vs. Arial spaced	20.58	10.11	21.07	9.99	-0.82	.42	-0.05
OpenDyslexic vs. TNR	20.20	10.04	18.78	9.70	2.33	.02	0.14
OpenDyslexic vs. Arial	20.20	10.04	20.58	10.11	-0.69	.49	-0.04
OpenDyslexic vs. TNR-S	20.20	10.04	20.02	10.30	0.32	.75	0.02
OpenDyslexic vs. Arial-S	20.20	10.04	21.07	9.99	-1.54	.13	-0.09
Passage- Accuracy	*M*	*SD*	*M*	*SD*	*t*(51)	*p*	Cohen's *d*
TNR vs. Arial	5.96	6.29	7.17	8.23	-2.27	.03	-0.17
TNR vs. TNR spaced	5.96	6.29	7.21	9.26	-1.80	.08	-0.16

Contrast	1		2				
Passage- Accuracy Cont.	*M*	*SD*	*M*	*SD*	*t*(51)	*p*	Cohen's *d*
Arial vs. Arial spaced	7.17	8.23	2.79	3.52	5.60	< .001	0.69
OpenDyslexic vs. TNR	7.67	9.88	5.96	6.29	2.08	.04	0.21
OpenDyslexic vs. Arial	7.67	9.88	7.17	8.23	0.76	.45	0.05
OpenDyslexic vs. TNR-S	7.67	9.88	7.21	9.26	0.66	.51	0.05
OpenDyslexic vs. Arial-S	7.67	9.88	2.79	3.52	4.61	< .001	0.66
Word Reading- Accuracy	*M*	*SD*	*M*	*SD*	*t*(54)	*p*	Cohen's *d*
TNR vs. Arial	1.95	2.38	2.18	2.83	-0.85	.40	-0.09
TNR vs. TNR spaced	1.95	2.38	2.15	2.58	-0.69	.50	-0.08
Arial vs. Arial spaced	2.18	2.83	2.51	2.70	-1.13	.26	-0.12
OpenDyslexic vs. TNR	2.53	2.92	1.95	2.38	1.59	.12	0.22
OpenDyslexic vs. Arial	2.53	2.92	2.18	2.83	1.28	.21	0.12
OpenDyslexic vs. TNR-S	2.53	2.92	2.15	2.58	1.51	.14	0.14
OpenDyslexic vs. Arial-S	2.53	2.92	2.51	2.70	0.06	.95	0.01
Non-Word- Accuracy	*M*	*SD*	*M*	*SD*	*t*(54)	*p*	Cohen's *d*
TNR vs. Arial	4.80	4.06	4.45	4.40	0.70	.49	0.08
TNR vs. TNR spaced	4.80	4.06	4.40	3.86	0.83	.41	0.10
Arial vs. Arial spaced	4.45	4.40	3.47	3.21	2.22	.03	0.25
OpenDyslexic vs. TNR	4.47	3.79	4.80	4.06	-0.72	.47	-0.08
OpenDyslexic vs. Arial	4.47	3.79	4.45	4.40	0.05	.96	0.005
OpenDyslexic vs. TNR-S	4.47	3.79	4.40	3.86	0.19	.85	0.02
OpenDyslexic vs. Arial-S	4.47	3.79	3.47	3.21	2.96	.005	0.28
Passage- Comprehension	*M*	*SD*	*M*	*SD*	*t*(51)	*p*	Cohen's *d*
TNR vs. Arial	84.23	17.42	83.46	18.03	0.28	.78	0.04
TNR vs. TNR spaced	84.23	17.42	92.69	12.54	-3.26	.002	-0.56
Arial vs. Arial spaced	83.46	18.03	91.15	12.78	-2.64	.01	-0.49
OpenDyslexic vs. TNR	91.92	12.69	84.23	17.42	2.51	.02	0.50
OpenDyslexic vs. Arial	91.92	12.69	83.46	18.03	2.89	.01	0.54
OpenDyslexic vs. TNR-S	91.92	12.69	92.69	12.54	-0.44	.66	-0.06
OpenDyslexic vs. Arial-S	91.92	12.69	91.15	12.78	0.34	.74	0.06

*TNR-S = Times New Roman- Spaced version; Arial-S = Arial- Spaced version

When considering serif versus sans serif, there was a significant difference in reading rate at the passage level between TNR (serif; M = 120.08, SD = 37.86) and Arial (sans serif; M = 114.02, SD = 38.86), $t(51) = 4.42$, $p < .001$, d = 0.16 indicating that students read more words per minute with serif font.

At the word level, there was a significant difference in reading rate between TNR (serif; M = 35.62, SD = 11.70) and Arial (sans serif; M = 34.42, SD = 11.92), $t(54) = 2.38$, $p = .02$, d = 0.10 indicating that students read more isolated words with serif font.

For non-word reading, the results showed that there was a significant difference in reading rate between TNR (serif; M = 18.78, SD = 9.70) and Arial (sans serif; M = 20.58, SD = 10.11), $t(54) = -2.95$, $p = .005$, d = -0.18 indicating that students read more non-words with Arial font.

Default Spacing versus Added Spacing. For the comparison of the default versus added spacing font types, there was a significant difference in reading rate at the passage level between TNR default spacing (M = 120.08, SD = 37.86) and TNR spaced (M = 113.29, SD = 36.28), $t(51) = 4.32$, $p < .001$, d = 0.18 indicating that students read more words per minute with default spacing. There was also a significant difference between Arial default spacing (M = 114.02, SD = 38.86) and Arial spaced (M = 144.02, SD = 39.96), $t(51) = -15.42$, $p < .001$, d = -0.76 indicating that students read more words per minute when reading text written in Arial with added spacing.

At the word level, no significant differences were found between TNR default spacing (M = 35.62, SD = 11.70) and TNR spaced (M = 35.16, SD = 12.21), $t(54) = 0.66$, $p = .51$, d = 0.04 or between Arial default spacing (*M* = 34.42, *SD* = 11.92) and Arial spaced (*M* = 33.29, *SD* = 11.49), *t*(54) = 1.92, *p* = .06, *d* = 0.10.

For non-word reading, there was a significant difference between the two spaced versions of TNR; TNR(default spacing; *M* = 18.78, *SD* = 9.70) and TNR spaced *M* = 20.02, *SD* = 10.30), *t*(54) = -2.09, *p* = .04, *d* = -0.12 indicating that students read more non-words with the spaced version of TNR font. No significant differences were found for non-word reading between Arial default spacing (*M* = 20.58, *SD* = 10.11) and Arial spaced (*M* = 21.07, *SD* = 9.99), *t*(54) = -0.82, *p* = .42, *d* = -0.05.

Dyslexia Font versus Other Fonts. For the dyslexia specific font type compared to the other fonts, only two of the fonts were different than OpenDyslexic- TNR and Arial with spacing. There was a significant difference between OpenDyslexic (*M* = 113.88, *SD* = 36.50) and TNR (*M* = 120.08, *SD* = 37.86), *t*(51) = -4.47, *p* < .001, *d* = -0.17. No significant differences were found at the passage level between OpenDyslexic (*M* = 113.88, *SD* = 36.50) and Arial (*M* = 114.02, *SD* = 38.86), *t*(51) = -0.10, *p* = .92, *d* = -0.004. No significant differences were found at the passage level between OpenDyslexic (*M* = 113.88, *SD* = 36.50) and TNR spaced (*M* = 113.29, *SD* = 36.28), *t*(51) = 0.41, *p* = .69, *d* = 0.02. There was a significant difference between OpenDyslexic (*M* = 113.88, *SD* = 36.50) and Arial spaced (*M* = 144.02, *SD* = 39.96), *t*(51) = -16.46, *p* < .001, *d* = -0.79.

At the word level, there was a significant difference between OpenDyslexic (*M* = 33.71, *SD* = 11.90) and TNR (serif; *M* = 35.62, *SD* = 11.70), *t*(54) = -3.07, *p* = .003, *d* = -0.16 indicating that students read more isolated words with TNR font. No significant differences were found between OpenDyslexic (*M* = 33.71, *SD* = 11.90) and Arial (*M* = 34.42, *SD* = 11.92), *t*(54) = -1.31, *p* = .20, *d* = -0.06. A significant difference was found between OpenDyslexic (*M* =

33.71, *SD* = 11.90) and TNR spaced (*M* = 35.16, *SD* = 12.21), *t*(54) = -2.37, *p* = .02, *d* = -0.12 indicating that students read more isolated words with TNR spaced font. No significant differences were found between OpenDyslexic (*M* = 33.71, *SD* = 11.90) and Arial spaced (*M* = 33.29, *SD* = 11.49), *t*(54) = 0.80, *p* = .43, *d* = 0.04.

When students read non-words, there was a significant difference between OpenDyslexic (*M* = 20.20, *SD* = 10.04) and TNR (serif; *M* = 18.78, *SD* = 9.70), *t*(54) = 2.33, *p* = .02, *d* = 0.14 indicating that students read more non-words with OpenDyslexic font. No significant differences were found between OpenDyslexic (*M* = 20.20, *SD* = 10.04) and Arial (*M* = 20.58, *SD* = 10.11), *t*(54) = -0.69, *p* = .49, *d* = -0.04. No significant differences were found between OpenDyslexic (*M* = 20.20, *SD* = 10.04) and TNR spaced (*M* = 20.02, *SD* = 10.30), *t*(54) = 0.32, *p* = .75, *d* = 0.02. Likewise, no significant differences were found between OpenDyslexic (*M* = 20.20, *SD* = 10.04) and Arial spaced (*M* = 21.07, *SD* = 9.99), *t*(54) = -1.54, *p* = .13, *d* = -0.09.

Effect of Font Features on Reading Accuracy

Serif versus Sans Serif. To determine what font characteristics had an impact on reading accuracy at the passage level, paired samples *t*-tests were used to analyze the font types. Reading accuracy was recorded by student errors, therefore, the lower the mean, the more accurate students read. There was a significant difference in reading accuracy between TNR (serif; *M* = 5.96, *SD* = 6.29) and Arial (sans serif; *M* = 7.17, *SD* = 8.23), *t*(51) = -2.27, *p* = .03, *d* = -0.17 indicating that students read with fewer errors when reading TNR.

At the word level, there were no significant differences between TNR (serif; *M* = 1.95, *SD* = 2.38) and Arial (sans serif; *M* = 2.18, *SD* = 2.83), *t*(54) = -0.85, *p* = .40, *d* = -0.09.

When students read non-words, there were no significant differences between TNR (serif; *M* = 4.80, *SD* = 4.06) and Arial (sans serif; *M* = 4.45, *SD* = 4.40), $t(54) = 0.70$, $p = .49$, $d = 0.08$.

Default Spacing versus Added Spacing. For the comparison of the default versus added spacing font types, there were no significant differences in reading accuracy at the passage level between TNR default spacing (*M* = 5.96, *SD* = 6.29) and TNR spaced (*M* = 7.21, *SD* = 9.26), $t(51) = -1.80$, $p = .08$, $d = -0.16$. There was a significant difference between Arial default spacing (*M* = 7.17, *SD* = 8.23) and Arial spaced (*M* = 2.79, *SD* = 3.52), $t(51) = 5.60$, $p < .001$, $d = 0.69$ indicating that students had fewer errors when reading text written in Arial with added spacing.

At the word level, no significant differences were found between TNR default spacing (*M* = 1.95, *SD* = 2.38) and TNR spaced (*M* = 2.15, *SD* = 2.58), $t(54) = -0.69$, $p = .5$, $d = -0.08$. Likewise, no significant differences were found between Arial default spacing (*M* = 2.18, *SD* = 2.83) and Arial spaced (*M* = 2.51, *SD* = 2.70), $t(54) = -1.13$, $p = .26$, $d = -0.12$.

For non-word reading, no significant differences were found between TNR default spacing (*M* = 4.80, *SD* = 4.06) and TNR spaced (*M* = 4.40, *SD* = 3.86), $t(54) = 0.83$, $p = .41$, $d = 0.10$. There was a significant difference between Arial default spacing (*M* = 4.45, *SD* = 4.40) and Arial spaced (*M* = 3.47, *SD* = 3.21), $t(54) = 2.22$, $p = .03$, $d = 0.25$ indicating that students had fewer errors while reading non-words with the Arial spaced font version.

Dyslexia Font versus Other Fonts. For the dyslexia specific font type compared to the other fonts, only two of the fonts were different than OpenDyslexic at the passage level- TNR and Arial with spacing. There was a significant difference between OpenDyslexic (*M* = 7.67, *SD* = 9.88) and TNR (*M* = 5.96, *SD* = 6.29), $t(51) = 2.08$, $p = .04$, $d = 0.21$ indicating that students read with fewer errors when reading text in TNR. No significant differences were found between

OpenDyslexic (*M* = 7.67, *SD* = 9.88) and Arial (*M* = 7.17, *SD* = 8.23), $t(51) = 0.76$, $p = .45$, $d = 0.05$. No significant differences were found between OpenDyslexic (*M* = 7.67, *SD* = 9.88) and TNR spaced (*M* = 7.21, *SD* = 9.26), $t(51) = 0.66$, $p = .51$, $d = 0.05$. There was a significant difference between OpenDyslexic (*M* = 7.67, *SD* = 9.88) and Arial spaced (*M* = 2.79, *SD* = 3.52), $t(51) = 4.61$, $p < .001$, $d = 0.66$ indicating that students read with fewer errors when reading text in Arial spacing compared to OpenDyslexic.

At the word level, no significant differences were found between OpenDyslexic (*M* = 2.53, *SD* = 2.92) and TNR (serif; *M* = 1.95, *SD* = 2.38), $t(54) = 1.59$, $p = .12$, $d = 0.22$. No significant differences were found between OpenDyslexic (*M* = 2.53, *SD* = 2.92) and Arial (*M* = 2.18, *SD* = 2.83), $t(54) = 1.28$, $p = .21$, $d = 0.12$. No significant differences were found between OpenDyslexic (*M* = 2.53, *SD* = 2.92) and TNR spaced (*M* = 2.15, *SD* = 2.58), $t(54) = 1.51$, $p = .14$, $d = 0.14$. No significant differences were found between OpenDyslexic (*M* = 2.53, *SD* = 2.92) and Arial spaced (*M* = 2.51, *SD* = 2.70), $t(54) = 0.06$, $p = .95$, $d = 0.01$.

When students read non-words, no significant differences were found between OpenDyslexic (*M* = 4.47, *SD* = 3.79) and TNR (serif; *M* = 4.80, *SD* = 4.06), $t(54) = -0.72$, $p = .47$, $d = -0.08$. No significant differences were found between OpenDyslexic (*M* = 4.47, *SD* = 3.79) and Arial (*M* = 4.45, *SD* = 4.40), $t(54) = 0.05$, $p = .96$, $d = 0.005$. No significant differences were found between OpenDyslexic (*M* = 4.47, *SD* = 3.79) and TNR spaced (*M* = 4.40, *SD* = 3.86), $t(54) = 0.19$, $p = .85$, $d = 0.02$. There was a significant difference between OpenDyslexic (*M* = 4.47, *SD* = 3.79) and Arial spaced (*M* = 3.47, *SD* = 3.21), $t(54) = 2.96$, $p = .005$, $d = 0.28$ indicating that students read text in Arial spaced font with fewer errors compared to OpenDyslexic.

Effect of Font Features on Reading Comprehension

Serif versus Sans Serif. To determine what font characteristics had the greatest impact on reading comprehension, a paired samples *t*-test was used to analyze the font types. No significant differences were found between TNR (serif; M = 84.23, SD = 17.42) and Arial (sans serif; M = 83.46, SD = 18.03), $t(51) = 0.28$, p = .78, d = 0.04.

Default Spacing versus Added Spacing. There was a significant difference in reading comprehension between TNR (default spacing; M = 84.23, SD = 17.42) and TNR spaced (M = 92.69, SD = 12.54), $t(51) = -3.26$, p = .002, d = -0.56. There was also a significant difference between Arial (default spacing; M = 83.46, SD = 18.03) and Arial spaced (M = 91.15, SD = 12.78), $t(51) = -2.64$, p = .01, d = -0.49. These results indicate that students achieved increased reading comprehension when reading fonts with increased spacing compared to default spacing.

Dyslexia Font versus Other Fonts. There was a significant difference between OpenDyslexic (M = 91.92, SD = 12.69) and TNR (M = 84.23, SD = 17.42), $t(51) = 2.51$, p = .02, d = 0.50. There was also a significant difference between OpenDyslexic (M = 91.92, SD = 12.69) and Arial (M = 83.46, SD = 18.03), $t(51) = 2.89$, p = .01, d = 0.54. No significant differences were found between OpenDyslexic (M = 91.92, SD = 12.69) and TNR space (M = 92.69, SD = 12.54), $t(51) = -0.44$, p = .66, d = -0.06. No significant differences were found between OpenDyslexic (M = 91.92, SD = 12.69) and Arial spaced (M = 91.15, SD = 12.78), $t(51) = 0.34$, p = .74, d = 0.06. These results indicated that students achieved increased reading comprehension when reading OpenDyslexic font compared to standard font types, but when those same fonts were presented with added spacing, there was no difference in comprehension between the dyslexia specific font and standard fonts with added spacing.

Group Differences in Reading Rate

A mixed model(s) repeated measures ANOVA was used to examine group and font on reading rate across the measures and between the two groups (i.e., Decoding Difficulties and Without Decoding Difficulties). Mauchly's Test of Sphericity was used to determine if the data met the assumption of sphericity. For reading rate at the passage level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 16.01, p = .067. The effect of font type on reading rate was significant, $F(4, 200) = 129.45$, $p < .001$. However, there was no statistically significant interaction effect between group and font on rate, $F(4, 200) = 1.26$, $p = .289$. See Figure 2 below.

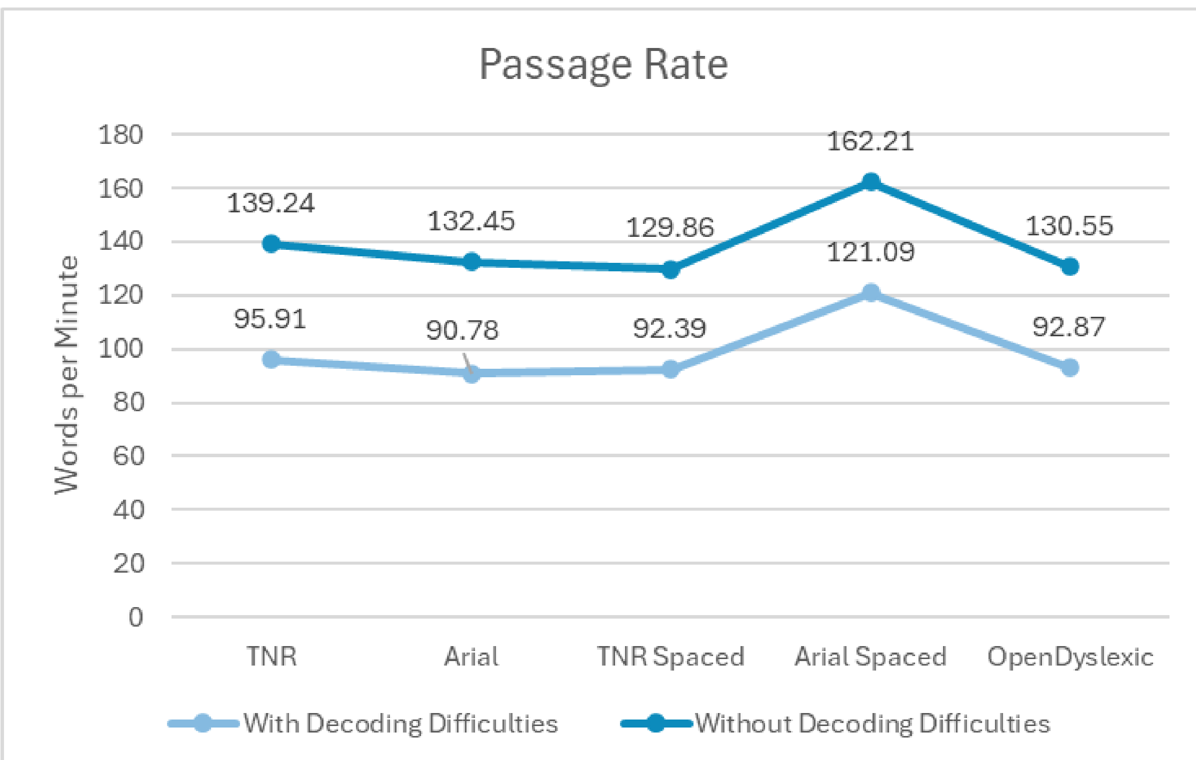

Figure 2. Group Passage Rate

For reading rate at the word level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 13.91, *p* = .126. The effect of font type on reading rate was significant, *F*(4, 212) = 5.32, *p* < .001. However, there was no statistically significant interaction effect of group and font on rate, *F*(4, 212) = 1.47, *p* = .214. See Figure 3 below.

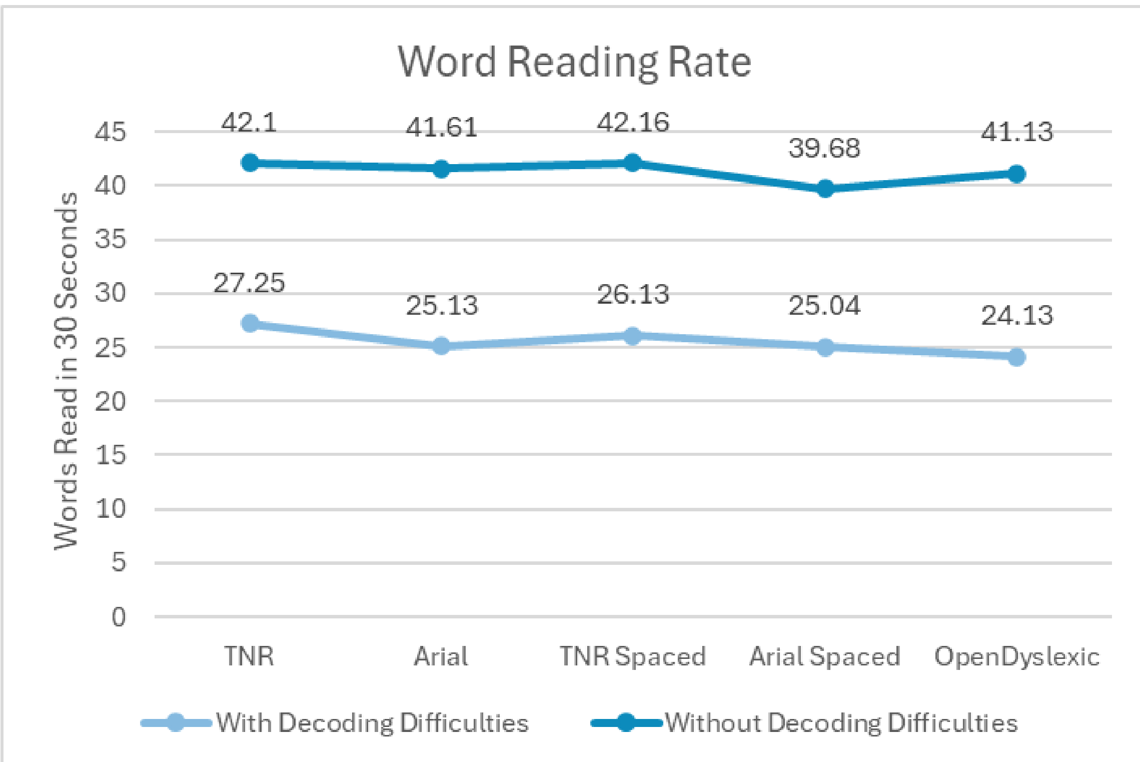

Figure 3. Group Word Reading Rate

For reading rate of non-words, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 4.33, *p* = .889. The effect of font type on reading rate was significant, *F*(4, 212) = 4.18, *p* = .003. However, there was no statistically significant interaction effect of group and font on rate, $F(4, 212) = 1.52$, $p = .199$. See Figure 4 below.

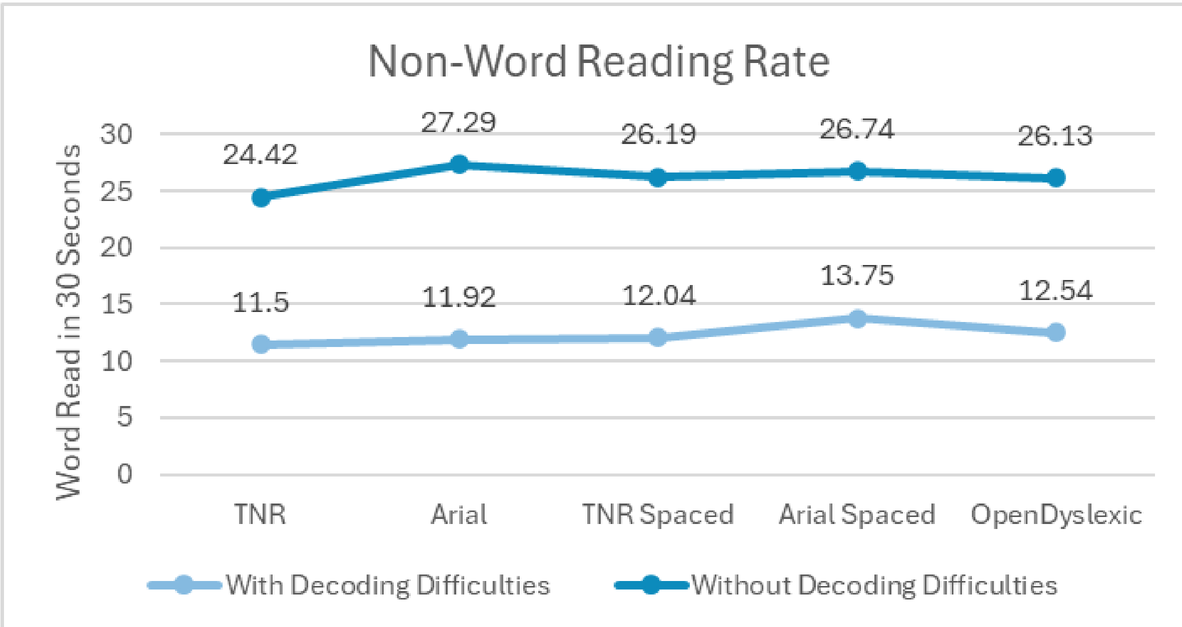

Figure 4. Group Non-Word Reading Rate

Group Differences in Reading Accuracy

For reading accuracy at the passage level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated x^2 (9) = 56.32, $p < .001$, so the degrees of freedom were corrected using Lower-bound. The effect of font type on reading accuracy at the passage level was significant, $F(1, 50) = 17.60$, $p < .001$. The effect of group and font on reading accuracy was significant, $F(1, 50) = 5.68$, $p = .021$ indicating that the effects of font was different for the two groups. Mean differences are reported in Table 7 and means by group are visually displayed in Figure 5.

Table 7

Group Mean Differences

Factors	Decoding Difficulties Mean Difference	*p*	Without Decoding Difficulties Mean Difference	*p*
		Passage- Rate		
TNR to Arial	5.13	.169	6.79*	.006
TNR to TNR Spaced	3.52	1.00	9.38*	<.001
Arial to Arial Spaced	-30.30*	<.001	-29.76*	<.001
TNR to OpenDyslexic	3.04	1.00	8.69*	<.001
Arial to OpenDyslexic	-2.09	1.00	1.90	1.00
TNR Spaced to OpenDyslexic	-0.48	1.00	-0.69	1.00
Arial Spaced to OpenDyslexic	28.22*	<.001	31.66*	<.001
		Word Reading- Rate		
TNR to Arial	2.13*	.007	0.48	.467
TNR to TNR Spaced	1.13	.285	-0.07	.944
Arial to Arial Spaced	0.08	.925	1.94*	.015
TNR to OpenDyslexic	-3.13*	.001	-0.97	.239
Arial to OpenDyslexic	-1.00	.232	-0.48	.509
TNR Spaced to OpenDyslexic	-2.000*	.037	-1.03	.214
Arial Spaced to OpenDyslexic	-0.917	.235	1.45*	.035
		Non-Word Reading- Rate		
TNR to Arial	-0.42	.644	-2.87*	<.001
TNR to TNR Spaced	-0.54	.548	-1.77*	.029
Arial to Arial Spaced	-1.83*	.044	0.55	.485
TNR to OpenDyslexic	1.04	.268	1.71*	.041
Arial to OpenDyslexic	0.63	.451	-1.16	.114
TNR Spaced to OpenDyslexic	0.50	.569	-0.07	.933
Arial Spaced to OpenDyslexic	-1.21	.167	-0.61	.423
		Passage- Accuracy		
TNR to Arial	-2.87*	.003	0.10	1.00
TNR to TNR Spaced	-2.74	.097	-0.07	1.00

Factors	Decoding Difficulties Mean Difference	*p*	Without Decoding Difficulties Mean Difference	*p*
Passage Accuracy Cont.				
Arial to Arial Spaced	7.57*	<.001	1.86	.467
TNR to OpenDyslexic	-3.00	.177	-0.69	1.00
Arial to OpenDyslexic	-0.13	1.00	-0.79	1.00
TNR Spaced to OpenDyslexic	-0.26	1.00	-0.62	1.00
Arial Spaced to OpenDyslexic	-7.70*	<.001	-2.66	.554
Word Reading- Accuracy				
TNR to Arial	-0.96*	.021	0.32	.368
TNR to TNR Spaced	-0.33	.457	-0.10	.806
Arial to Arial Spaced	0.63	.129	-1.07*	.004
TNR to OpenDyslexic	1.04	.065	0.23	.644
Arial to OpenDyslexic	0.08	.84	0.55	.134
TNR Spaced to OpenDyslexic	0.71	.07	0.13	.703
Arial Spaced to OpenDyslexic	0.71	.095	-0.52	.165
Non-Word Reading- Accuracy				
TNR to Arial	0.46	.548	0.26	.70
TNR to TNR Spaced	0.50	.501	0.32	.621
Arial to Arial Spaced	1.17	.09	0.84	.164
TNR to OpenDyslexic	-0.46	.509	-0.23	.711
Arial to OpenDyslexic	0.00	1	0.03	.951
TNR Spaced to OpenDyslexic	0.04	.944	0.10	.853
Arial Spaced to OpenDyslexic	1.17*	.027	0.87	.06
Passage- Comprehension				
TNR to Arial	0.87	1.00	0.69	1.00
TNR to TNR Spaced	-6.96	.83	-9.66	.081
Arial to Arial Spaced	-5.22	1.00	-8.28	.36
TNR to OpenDyslexic	-9.57	.446	-6.21	1.00
Arial to OpenDyslexic	-0.87	1.00	-0.69	1.00
TNR Spaced to OpenDyslexic	-7.83	.631	-10.35	.068
Arial Spaced to OpenDyslexic	-6.09	1.00	-8.97	.269

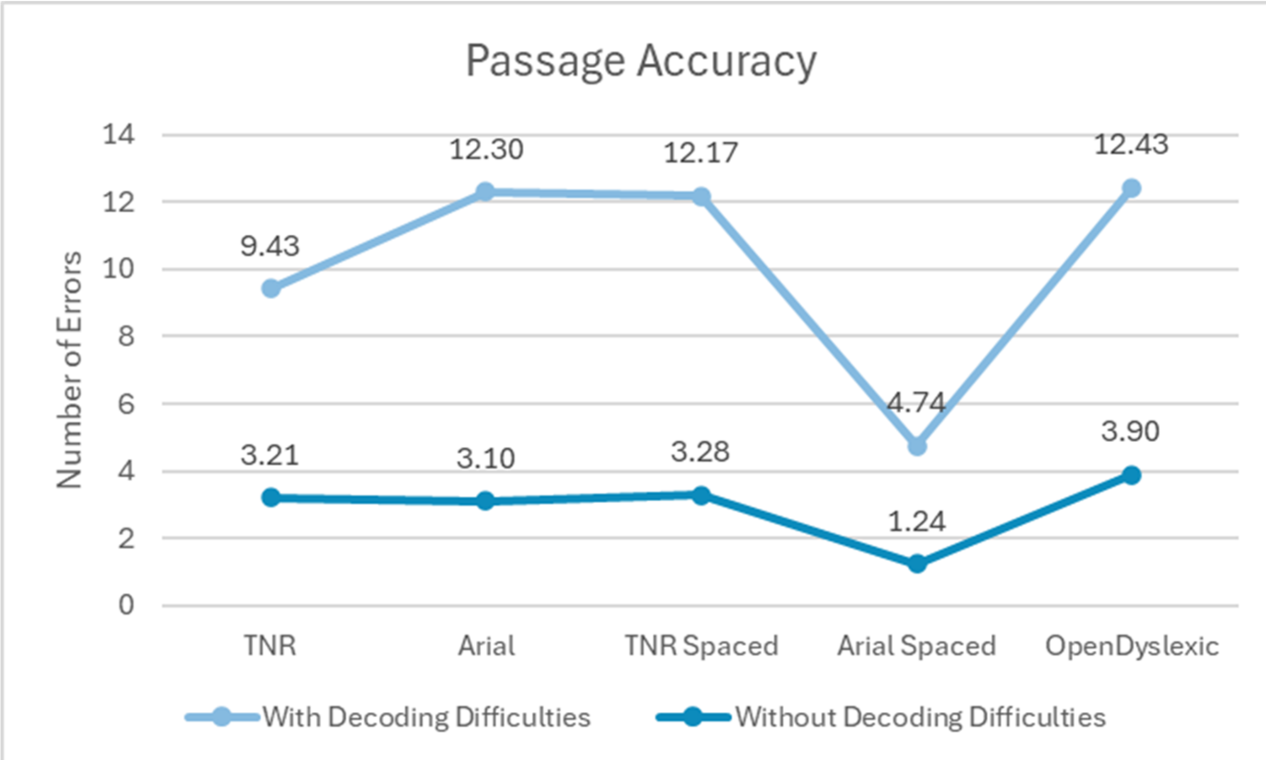

Figure 5. Group Passage Accuracy

For reading accuracy at the word level, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated x^2 (9) = 20.37, *p* = .016, so the degrees of freedom were corrected using Lower-bound. The effect of font type on reading accuracy was not statistically significant, *F*(1, 53) = 1.64, *p* = .206. There was no statistically significant interaction effect of group and font on accuracy, *F*(1, 53) = 2.86, *p* = .097. See Figure 6 below.

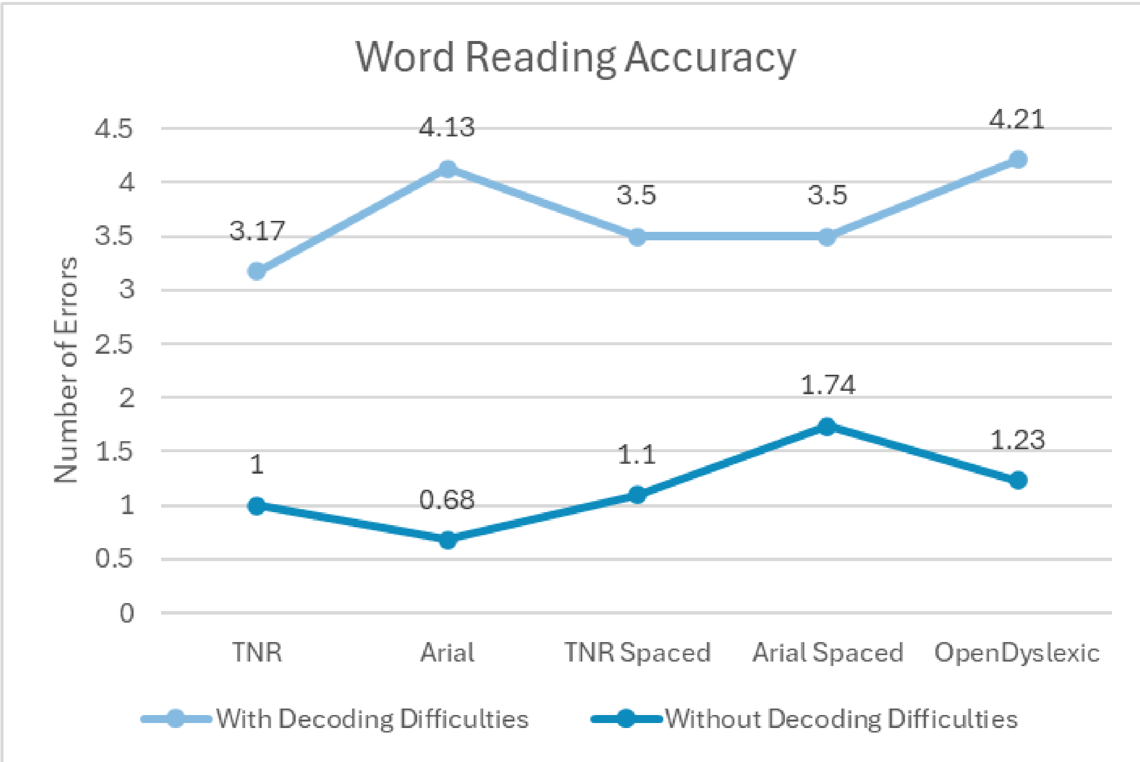

Figure 6. Group Word Reading Accuracy

For reading accuracy of non-words, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated x^2 (9) = 11.79, *p* = .226. The effect of font type on reading accuracy was statistically significant, *F*(4, 212) = 2.78, *p* = .028. However, there was not a statistically significant interaction effect of group and font on accuracy, *F*(4, 212) = 0.10, *p* = .983. See Figure 7 below.

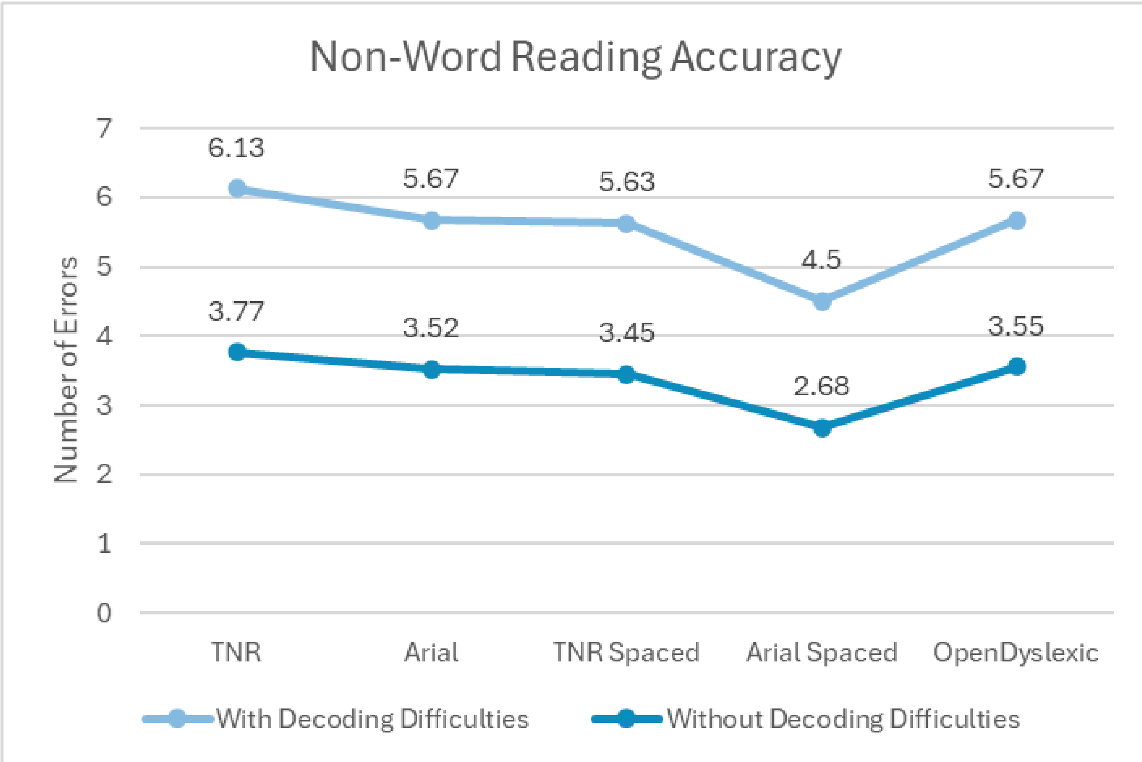

Figure 7. Group Non-Word Reading Accuracy

Group Differences in Reading Comprehension

For Reading Comprehension, Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated x^2 (9) = 28.54, $p < .001$, so the degrees of freedom were corrected using Lower-bound. The effect of font type on reading comprehension was significant, $F(1, 50) = 5.61$, $p = .022$. However, there was no statistically significant interaction effect of group and font on reading comprehension, $F(1, 50) = 0.47$, $p = .495$. See Figure 8 below.

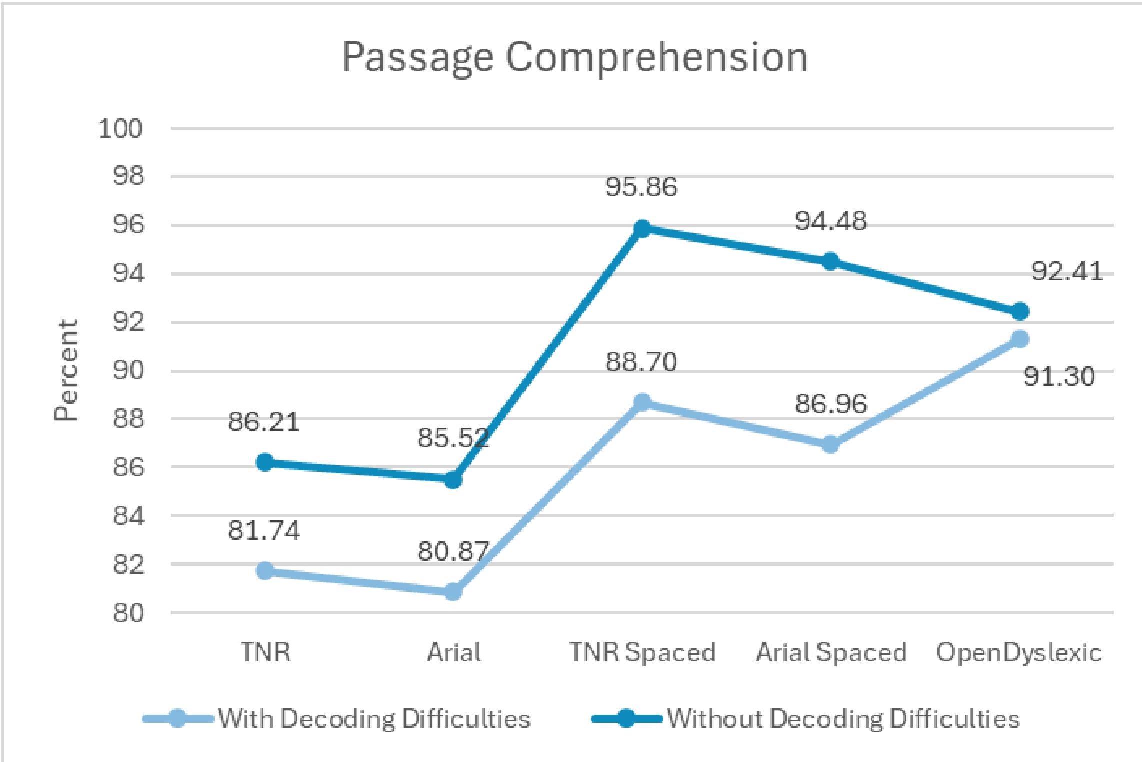

Figure 8. Group Passage Comprehension

Perception of Font Type

The final set of analyses were completed to determine students' perceptions of the various font types within the study. The Preference Assessment consisted of a five-point scale where students placed the numbers 1 through 5 on identical passages that differed only by font type (i.e., 1 = liked the least; 5 = liked the most). The sums of the rankings are displayed in Figure 9.

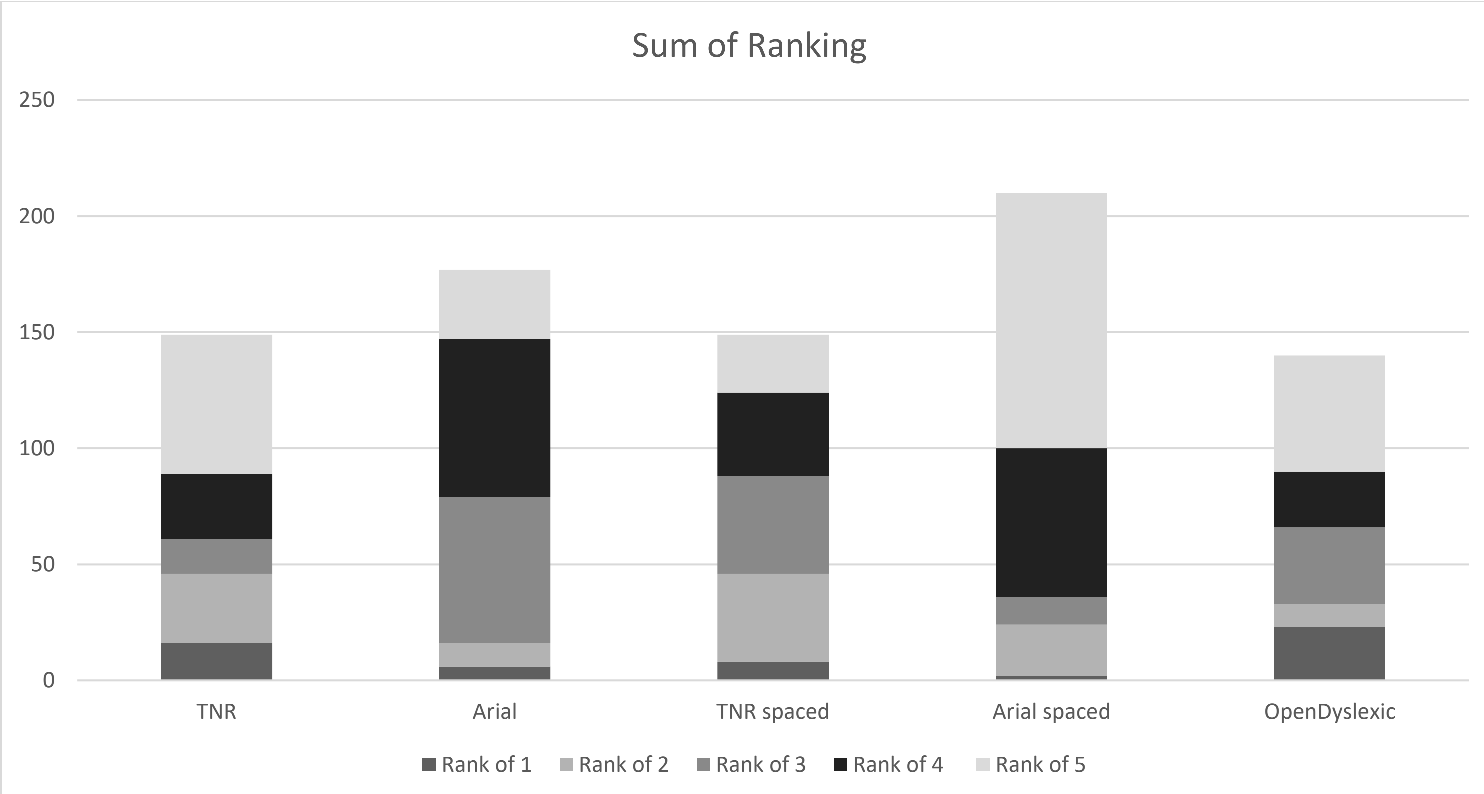

Figure 9. Font Preference

Note: All 55 students were given the Preference Assessment. 1 = liked the least; 5 = liked the most

Arial with added spacing was preferred by most students (i.e., sum of ranking = 210). The least preferred font type was OpenDyslexic (i.e., sum of ranking = 140). When students were asked why they preferred one font over another, students noted that Arial with additional spacing seemed easier to read due to its size and boldness. The students who preferred OpenDyslexic the least said that the font was distracting.

CHAPTER V: DISCUSSION

Dyslexia-specific and altered fonts have existed for almost twenty years. These fonts were developed to assist individuals with dyslexia to be more proficient readers by improving their reading fluency and accuracy, areas of deficit for most individuals with dyslexia. By modifying letter shapes and spacing, these fonts were said to reduce visual crowding and letter confusion. However, their effectiveness remains inconclusive with mixed effects across prior research. The current study measured the effects of dyslexia specific and altered fonts compared to standard fonts on reading accuracy, reading rate, and reading comprehension for students with and without decoding difficulties. This chapter gives an overview of the general findings, discusses possible limitations of the research, gives suggestions for future research, and provides practical implications of altered font use.

General Findings

Across all participants, while reading connected text, students read more words per minute in Arial with added spacing and had greater accuracy compared to the other font types. The results of non-word reading measures were similar to passage reading as students read a greater number of words and had greater accuracy when reading non-words written in Arial with added spacing.

The opposite was true when students read lists of real words. In fact, students read the least number of decontextualized words in Arial with added spacing. Students had more errors when reading words in Arial with added spacing compared to three of the other four font types while reading words. OpenDyslexic errors were comparable to Arial with added spacing when students read isolated words. Students had the greatest rate and accuracy while reading real words in the serif font, TNR, in the default spaced condition, although there were little differences between the font types. Joo et al. (2018) suggest that visual crowding is not as likely to hinder single word reading as much as reading words in connected text since spacing is already applied as there is a greater amount of white space on the page. While in this research, word and non-word reading had opposite results, it could likely be due to the fact that non-words require more effort as reading them requires application of phonics rules while many real words can be retrieved from memory and read automatically without having to sound them out.

For passage comprehension, students scored higher when reading text written in TNR with added spacing, although the scores were more comparable to the other two fonts with increased spacing (i.e., Arial with added spacing and OpenDyslexic). These results are consistent with the findings of French et al. (2013) who found that comprehension ability was increased when reading text written in a serif font type compared to sans serif. However, the scores indicated a ceiling effect on the comprehension measure, suggesting that these results should be interpreted with caution.

As expected, when looking at the differences between the two groups, students without decoding difficulties read more efficiently than students with decoding difficulties. Students without decoding difficulties read with greater ability than students with decoding difficulties. However, when comparing the differences between fonts by group, there were few differences between the groups. At the group level and comparing font to font, groups showed no differences in reading rate across the font types when reading passages, words, and non-words. Students with and without decoding difficulties did have greater accuracy when reading text written in Arial with added spacing, although these effects were more substantial for the group with decoding difficulties. This aligns with the previous findings of Joo et al. (2018), who discovered that students with reading difficulties benefited from increased spacing, whereas those who were already proficient readers showed little to no improvement in accuracy. However, this could have been due to ceiling effects, as students without decoding difficulties had little room for improvement for reading accuracy.

For passage comprehension, the group with decoding difficulties had greater comprehension when reading text written in TNR with added spacing. Although TNR with added spacing did not outperform all of the fonts for students without decoding difficulties, it was comparable to the other two spaced fonts, Arial and OpenDyslexic. Likewise, Perea et al. (2012) found that when compared to the default spaced version, TNR with added spacing increased comprehension for students with dyslexia but did not have a negative impact for students who were typical readers. However, it should be noted that nearly all students scored 60% or above.

Across all students, Arial with added spacing was the preferred font type. Students liked the way the print looked, and although the size remained consistent across all font types, students noted that it looked larger. OpenDyslexic was the least preferred font type. Students commented that it was distracting and more difficult to read. This is consistent with the findings of Rello and Baez-Yates (2013) who found that participants preferred the standard font types of Verdana or Helvetica (both sans serif font types) over OpenDyslexic.

Limitations

Although this study provides useful information on font type, there are limitations of the current research. The sample size was relatively small. A priori power analysis estimated a necessary sample size in excess of 1,000 students per group. Since this vast number of students was not reasonably attainable, prior research was examined. The participants were from one single school district and were accessible within one school. By adding additional locations, a greater number of participants could have been achieved thus increasing statistical power.

The groups themselves were a limitation as they consisted of a large number of students with decoding difficulties versus students without decoding deficits. This would likely indicate that the school has a higher-than-average number of students with decoding difficulties. It was expected that based on the percentage of students of the population that participated in the study, there would be a greater number of students without decoding difficulties based on the 25th percentile cut-off to identify the groups.

The cut-off scores were another limitation. Although there is not a huge discrepancy between a student who scores 25 and another student who scores 26, cut-off scores were necessary to identify groups. With a greater number of student participants, there could have been a larger discrepancy between the groups. For example, students with decoding difficulties could be identified at or below the 10th percentile and students without decoding difficulties above the 50th percentile. This would create a vast distinction between those who were able to decode words adequately and those who could not.

An additional limitation was the passages. Although the five passages did not vary greatly, there were differences in length, readability, and subject matter. Despite the fact that all five of the passages were at the third-grade level, they varied from 4-500 to 6-700 Lexile levels. This likely impacted how well the students were able to read the passages. In this study, we decided to control for the presentation of repeated passages as has been done in previous studies. Future studies should consider better equating the passages or presenting the same passage in different fonts using a counterbalanced design to control for passage difficulty. There was also no way of controlling prior knowledge of students. Prior knowledge can highly influence a student's ability to read a passage fluently and understand it. Therefore, outcomes may have been influenced by students' prior exposure to printed materials. Future studies should consider administering measures to assess prior knowledge and prior print exposure.

A final limitation was possible ceiling effects for some readers. The sample consisted of students from grades three through five while the passages were at the third-grade level. While the idea behind the lower-level passages was that it provided access to all students, this created a ceiling effect as many students performed well regardless of alterations to font. These students did not have room to improve. Many students made no errors while reading and this included the group with decoding difficulties.

Future Research

Overall, Arial with added spacing seemed to have the greatest impact on readability. OpenDyslexic did not provide increased reading ability compared to standard fonts, although students with decoding difficulties showed better reading comprehension when reading text written in OpenDyslexic compared to the other font types. By adding spacing to passages, all students read more words per minute and read them more accurately. However, this did not transfer to word and non-word reading. Additional research should be done in the area of altered font types on readers' ability to read text.

One area of possible research would be to examine how altered fonts impact different age groups. Ehri (1995) outlined how early readers progress from relying on visual cues to automatic word reading. It would be important to determine if there would be differences in the effects of altered fonts between the various stages of development in reading.

Future research should look at the effects of altered font on sustained reading. Readers rarely read words in isolation and most often read books or articles in their entirety. Digital print versus altered font on print on paper would be another area of relevance given today's reliance on technology. In their meta-analysis, Clinton (2019) found that digital print had negative effects over text printed on paper on reading performance. However, font type was not considered within this research.

Although this study did not manipulate font size, future work in the area of font type on readability should look at the size of font along with additional spacing as previous research has shown that increasing font size alone benefited reading rate (Ismail & Jaafar, 2018).

One final area of future research would be to examine the impact of altered fonts on more difficult text. Since ceiling effects limited the results of the current study, using a more difficult text could better assess whether altered fonts impact decoding ability, as more difficult text is likely to include words that are not recognized automatically.

Practical Implications

The study findings suggest that specific fonts may be beneficial to certain readers. These findings have important implications for various domains, including education, digital media, and accessibility features. The findings suggest that choice of font may make a difference in student performance. This is important when considering student screening data. Students completing oral reading fluency benchmarks in certain fonts may do better or worse depending on the font that the measure uses. By ensuring readability, assessments may provide more accurate evaluations of student ability. More research will need to be completed to better understand the impact of fonts in measurements such as oral reading fluency, but these findings suggest that font may need to be considered when establishing and interpreting normative data.

For educators, selecting fonts that improve readability can in turn enrich student learning. Individuals with dyslexia may benefit from font choices that maximize accuracy and improve comprehension. This could be used as an immediate accommodation in most digital formats. Graphic designers and book publishers should consider how typography affects user experience while ensuring that text remains clear and engaging.

In conclusion, this study provides highlights of the role of font on readability including reading rate, accuracy, and comprehension. Although altered fonts should never be used as an alternative to systematic literacy instruction and evidence-based interventions, altered fonts could serve as an accessibility feature to improve reading for many individuals.

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APPENDICES

APPENDIX A

Comprehension Measure

Comprehension Questions for "To Be a Poet"

1. In the passage "To Be a Poet," what time of the day did the narrator begin their walk?
    a. Morning
    b. Afternoon
    c. Evening
    d. Night

2. What was the season of the year?
    a. Spring
    b. Summer
    c. Fall
    d. Winter

3. Where was the narrator intending to walk to?
    a. Pittsburg
    b. Phoenix
    c. Prague
    d. Paris

4. Why was the narrator quiet?
    a. They did not want to wake mother.
    b. They did not want to wake brother.
    c. They were late.
    d. They were tired.

5. What did the narrator do when they stopped at the inn?
    a. They stopped to stay the night.
    b. They were meeting the man with green overalls.
    c. They drank water from the well.
    d. They were meeting with the girls from school.

Comprehension Questions for "The Chest"

1. Where was the chest that Andrew and Tracy were exploring?
    a. In the basement
    b. In the attic
    c. In Andrew's room
    d. In Tracy's room

2. What type of key did Andrew have to open the chest?
    a. A silver key
    b. A black key
    c. A brass key
    d. An old key

3. How did Andrew feel as he was trying to open the chest?
    a. Scared
    b. Mad
    c. Happy
    d. Indifferent

4. As Andrew lifted the lid of the chest, he said…
    a. "Wow, this smells bad."
    b. "Wow, this is old."
    c. "Wow, let's look inside."
    d. "Wow, it's heavy."

5. How did the chest smell once it was opened?
    a. Like a ray of sunlight
    b. Musty
    c. Like a warm summer rain
    d. Misty

Comprehension Questions for “The Tight Rope”

1. What did Clara tie the rope to make a tight rope?
    a. Two oak trees
    b. Two maple trees
    c. Two hemlock trees
    d. Two pine trees

2. What was Clara wearing?
    a. Pink sandals
    b. Yellow silk ballet slippers
    c. Pink skirt
    d. Yellow jumper

3. What did the rope do as Clara walked to the other side?
    a. The rope shook.
    b. The rope straightened.
    c. The rope fell.
    d. The rope tangled.

4. How did Clara keep her balance?
    a. She held a stick.
    b. She raised and lowered her legs.
    c. She raised and lowered her arms.
    d. She balanced on one foot.

5. Who was watching Clara walk across the tight rope?
    a. Her mom
    b. Her little sister
    c. Her friend Sarah
    d. Her friend Charles

Comprehension Questions for "The Best Birthday Ever"

1. What did the mom make for breakfast?
    a. Bacon and eggs
    b. Waffles and eggs
    c. Pancakes and bacon
    d. Eggs and toast

2. What did she use to make a happy face?
    a. Chocolate chips
    b. Strawberry syrup
    c. Strawberries and blueberries
    d. Whipped cream

3. Who did mom invite to the birthday party?
    a. Friends and family
    b. Her classmates
    c. Neighbors
    d. Her best friend

4. What did everyone do at the party?
    a. Bowling
    b. Played in the pool
    c. Ate cake and left
    d. Skated and played games

5. What did everyone do at the party after the narrator opened their gifts?
    a. Skate
    b. Left
    c. Ate cake
    d. Sang happy birthday

Comprehension Questions for “The Man Who Lived in a Hollow Tree”

1. How did the man sleep in the hollow tree?
    a. On a branch
    b. Curled up into a ball
    c. Standing up
    d. Lying down

2. What could people see when the man spoke?
    a. People could not see the man.
    b. People could only see his mouth through a hole in the tree.
    c. People could only see his feet at the bottom of the tree.
    d. People could only see the man’s arms.

3. How did the man eat?
    a. The man did not eat.
    b. People gave him sandwiches.
    c. The birds brought the man food.
    d. People spooned food through the hole in the tree.

4. Why was the man not lonely?
    a. The birds and a squirrel kept him company.
    b. A dog would visit often.
    c. The tree kept him company.
    d. The wind would whisper to him when the people were away.

5. What did the man say when people asked how he got inside the tree?
    a. He dug his way underneath the tree.
    b. What does it matter how?
    c. The tree grew up around him.
    d. He would keep it a secret.

Answer Key for "To Be a Poet"

1. In the passage "To Be a Poet", what time of the day did the narrator begin their walk?

    A. Morning

2. What was the season of the year?

    B. Summer

3. Where was the narrator intending to walk to?

    D. Paris

4. Why was the narrator quiet?

    A. They did not want to wake mother.

5. What did the narrator do when they stopped at the inn?

    C. They drank water from the well.

Answer Key for "The Chest"

1. Where was the chest that Andrew and Tracy were exploring?
   B. In the attic

2. What type of key did Andrew have to open the chest?
   C. A brass key

3. How did Andrew feel as he was trying to open the chest?
   A. Scared

4. As Andrew lifted the lid of the chest, he said…
   D. "Wow, it's heavy."

5. How did the chest smell once it was opened?
   B. Musty

Answer Key for "The Tight Rope"

1. What did Clara tie the rope to in order to make a tight rope?
   D. Two pine trees

2. What was Clara wearing?
   B. Yellow silk ballet slippers

3. What did the rope do as Clara walked to the other side?
   A. The rope shook.

4. How did Clara keep her balance?
   C. She raised and lowered her arms.

5. Who was watching Clara walk across the tight rope?
   D. Her friend Charles

Answer Key for "The Best Birthday Ever"

1. What did the mom make for breakfast?
   B. Waffles and eggs

2. What did she use to make a happy face?
   C. Strawberries and blueberries

3. Who did mom invite to the birthday party?
   A. Friends and family

4. What did everyone do at the party?
   D. Skate and played games

5. What did everyone do at the party after the narrator opened their gifts?
   A. Skate

Answer Key for “The Man Who Lived in a Hollow Tree”

1. How did the man sleep in the hollow tree?
   C. Standing up

2. What could people see when the man spoke?
   B. People could only see his mouth through a hole in the tree.

3. How did the man eat?
   D. People spooned food through the hole in the tree.

4. Why was the man not lonely?
   A. The birds and a squirrel kept him company.

5. What did the man say when people asked how he got inside the tree?
   B. What does it matter how?

APPENDIX B

Word and Non-Word Reading Measures

Directions for Administrating the Word and Non-Word Reading Measures:

Provide the student with Word/Non-Word Reading Measure form A, B, C, D, or E. Place the appropriate form face down on the table.

You are going to read a list of words/non-words. You will have 30 seconds to read as many words/non-words as you can. Try your best but do not take much time on a single word. If you do not know the word/non-word, skip it and go to the next word (or non-word). You will read down the first column and once you have finished, read down the next column. If you finish both columns, continue here (Administrator points to the top of the first column).

Demonstrate with an example.

Do you have any questions?

Answer any student questions. Set the timer for 30 seconds, turn the test form over. Begin timer as student reads the first word/non-word.

Word Reading Measure A

Times New Roman

hit	crept
leg	stroke
sad	toast
chop	clump
trim	thin
help	beak
flag	spin
stop	greet
bend	faith
lamp	spite
brush	fry
path	bright
dust	spoil
shop	jerk
chin	birch
crisp	turn
grand	slept
stamp	drop
tape	meet
fail	plan
stray	brim
flake	rent
treat	camp
note	belt
load	fast

Word Reading Measure B

Arial

rat	shelf
map	grope
let	coast
desk	speed
spent	crust
shot	beam
clap	strip
hush	greed
send	steal
damp	chip
spine	sly
bath	foil
rust	sight
stump	perk
drum	firm
brisk	burn
crash	flip
grasp	crust
mate	fresh
pain	print
gray	smash
rate	grant
claim	rate
hope	bait
moat	pray

Word Reading Measure C

TNR with Added Spacing

hut	swept
red	froze
mat	croak
trip	plump
drag	weed
spot	deal
flap	slid
gain	creep
sent	steam
bump	blush
felt	shy
slid	fright
must	herd
blush	joint
soak	birth
burst	swift
stand	whale
trash	stain
slope	pale
task	foam
clay	check
slave	throne
waist	cloak
robe	stripe
shelf	deep

Word Reading Measure D

Arial with Added Spacing

sat	flesh
rub	shone
met	groan
trap	cluck
chill	seem
flop	meal
crush	shin
snap	cheek
tent	plead
dump	slide
melt	dry
grain	flight
rush	spin
moist	verb
leash	shirt
rage	church
plant	bead
brand	spit
shift	code
fern	swept
sway	ripe
coil	spy
past	fight
speed	stale
loaf	wait

Word Reading Measure E

OpenDyslexic

hat	loan
ted	speck
sit	plop
rode	roast
drip	stole
slash	bleed
glad	neat
slip	seed
faint	least
lump	shine
nest	dry
math	tight
dusk	broil
stunt	clerk
farm	dirt
chimp	afraid
flash	stir
trot	churn
fade	crest
tray	group
maid	never
slate	fact
mend	nation
slop	hurt
trust	equal

Non- Word Reading Measure A

Times New Roman

dat	troat
len	bep
dom	spofe
spoab	drin
shan	rud
clim	creat
pleep	flom
gand	mib
somp	trit
lesk	sneaf
gath	mib
fust	smy
swigh	trant
plomp	chom
frist	snerd
skirb	melp
gresh	snurk
baff	loit
tade	dreeb
baim	stam
skay	flid
flape	thop
smaip	fand
chon	gomp
troke	drast

Non-Word Reading Measure B

Arial

dut	troak
lep	fleef
trin	plobe
dram	spoaf
spad	nist
flim	smeed
slon	pleap
tib	sant
tomp	mep
selt	dreab
hask	sile
swy	waff
pront	sloam
slamp	noip
brist	skerm
snird	frast
glest	skurb
sath	flaip
bame	hust
jait	drant
smay	slomp
flabe	brigh
praft	tud
dom	flest
paff	grisp

Non- Word Reading Measure C

TNR with Added Spacing

gat	sloam
rup	dep
smead	swofe
chot	ploab
flad	rine
snig	sleed
trop	gast
lant	fleaf
fomp	smeeb
relt	kib
slape	spon
lish	bry
fland	grigh
blomp	loip
grish	slert
trasp	presh
skirm	snurd
maff	brate
jate	taid
blait	blay
snay	smape
pud	traig
flaib	som
lom	trote
froke	skoad

Non- Word Reading Measure D

Arial with Added Spacing

lat	froak
rem	tep
trib	flobe
drim	swoaf
plat	nud
glim	greep
jaff	slead
pand	dib
homp	sweef
lath	tud
hest	sipe
misk	gry
flamp	snigh
skurm	poig
groaf	merch
prask	slirt
glept	plond
slom	fep
blate	spobe
spail	trisp
kray	smeab
plabe	creet
slaip	slean
hom	gib
smope	sneef

Non- Word Reading Measure E

OpenDyslexic

dit	smoap
lam	rast
chib	grofe
dant	floab
shab	brom
plin	greap
brom	steen
tub	pib
snirk	sneeb
gelt	prast
rast	mife
nush	sny
dramp	bligh
slont	toig
frisp	snerk
sweaf	mirch
glesh	slurt
naff	chay
spale	gine
brait	bly
sneab	smigh
trabe	toip
plaib	skerb
jom	lomp
skode	murch

APPENDIX C

Font Preference Measure

Numbers to cut out

1	2	3	4	5

Place the Font Preference example pages A-E in front of the student. Give the student the cut-out numbers 1-5.

I will give you the numbers 1 to 5. Look at all of the pages. The words on each of the pages are exactly the same. Now, place the 5 on the page that you like the most. Looking at the pages left, which one do you like the most and place the 4 on that page.

Continue with 3, 2, and finally have the student place the 1 on the last page.

You placed the 5 on (A, B, C, D, or E). Can you tell me why you picked this page?

You placed the 1 on (A, B, C, D, or E). Can you tell me why you picked this page?

Record the student's responses on a blank sheet of paper.

Font A

Times New Roman

One bright day in late autumn a family of Ants were bustling about in the warm sunshine, drying out the grain they had stored up during the summer, when a starving Grasshopper, his fiddle under his arm, came up and humbly begged for a bite to eat. "What!" cried the Ants in surprise, "haven't you stored anything away for the winter? What in the world were you doing all last summer?"

Excerpt from: The Ants and the Grasshopper. Aesop’s Fables.

Retrieved from: Aesop's Fables Interactive Book | Read.gov - Library of Congress

Font B

Arial

One bright day in late autumn a family of Ants were bustling about in the warm sunshine, drying out the grain they had stored up during the summer, when a starving Grasshopper, his fiddle under his arm, came up and humbly begged for a bite to eat. "What!" cried the Ants in surprise, "haven't you stored anything away for the winter? What in the world were you doing all last summer?"

Excerpt from: The Ants and the Grasshopper. Aesop's Fables.

Retrieved from: Aesop's Fables Interactive Book | Read.gov - Library of Congress

Font C

TNR with Added Spacing

One bright day in late autumn a family of Ants were bustling about in the warm sunshine, drying out the grain they had stored up during the summer, when a starving Grasshopper, his fiddle under his arm, came up and humbly begged for a bite to eat. "What!" cried the Ants in surprise, "haven't you stored anything away for the winter? What in the world were you doing all last summer?"

Excerpt from: The Ants and the Grasshopper. Aesop’s Fables.

Retrieved from: Aesop's Fables Interactive Book | Read.gov - Library of Congress

Font D

Arial with Added Spacing

One bright day in late autumn a family of Ants were bustling about in the warm sunshine, drying out the grain they had stored up during the summer, when a starving Grasshopper, his fiddle under his arm, came up and humbly begged for a bite to eat. "What!" cried the Ants in surprise, "haven't you stored anything away for the winter? What in the world were you doing all last summer?"

Excerpt from: The Ants and the Grasshopper. Aesop's Fables.

Retrieved from: Aesop's Fables Interactive Book | Read.gov - Library of Congress

Font E

OpenDyslexic

One bright day in late autumn a family of Ants were bustling about in the warm sunshine, drying out the grain they had stored up during the summer, when a starving Grasshopper, his fiddle under his arm, came up and humbly begged for a bite to eat. "What!" cried the Ants in surprise, "haven't you stored anything away for the winter? What in the world were you doing all last summer?"

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