The Relationship of an iPad, a Video Magnifier, and Large Print Text with Oral Reading Outcomes for Children with Low Vision

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THE RELATIONSHIP OF AN IPAD, A VIDEO MAGNIFIER, AND LARGE PRINT TEXT WITH ORAL READING OUTCOMES FOR CHILDREN WITH LOW VISION

by

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A dissertation submitted to the Graduate College in partial fulfillment of the requirements for the Degree of Doctor of Philosophy
Interdisciplinary Health Sciences
Western Michigan University
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Rosemary L. Nave Stawasz
THE RELATIONSHIP OF AN IPAD, A VIDEO MAGNIFIER, AND LARGE PRINT TEXT WITH ORAL READING OUTCOMES FOR CHILDREN WITH LOW VISION

Rosemary L. Nave Stawasz, Ph.D.

Western Michigan University, 2019

Low vision may cause a decrease in visual performance and interfere with daily functioning, especially reading print or text materials. Reading standard text can be particularly challenging for students with low vision in an educational setting and can reduce oral reading rates. Students with low vision may use large print or low vision devices for reading. Limited evidence currently exists to compare oral reading outcomes across various reading media for children with low vision.

The purpose of this exploratory project was to examine oral reading rate, fluency, and comprehension among children with low vision when using an iPad, a video magnifier, and large print text. There were three participants with low vision with one student in third grade and two students in fourth grade. This study used a repeated acquisition single-subject research design. A pretest and posttest measure was given using the Neale Analysis of Reading Ability (NARA). Eighteen different oral reading assessment passages at one’s independent reading level were administered to all participants over six weeks. All participants used an iPad, a video magnifier, and large print text to read different passages. Data for each child was analyzed by examining and comparing the oral reading measures within and across conditions. The visual analysis determined that a functional relation did not exist between using the iPad, video magnifier, or
large print text on oral reading rate, fluency, and comprehension. The results, limitations, and implications for practitioners are discussed.
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CHAPTER I

INTRODUCTION

This dissertation aims to explore the relationship of reading large print text, on an iPad, and a video magnifier with oral reading rate, fluency, and comprehension for children with low vision. This introduction will begin by discussing the importance of oral reading rate, fluency, and comprehension among students. Next, the various reading media that children with low vision can use to read print materials will be described. Research questions have been developed to address whether a particular method of accessing print materials will affect the oral reading rate, fluency, and comprehension among the students.

Definition of Terms

In an educational setting, visual impairment is defined as any visual condition that adversely impacts educational performance (IDEA, 2004). Some states have used the following criteria in the past: visual acuity of less than 20/70 in the better eye with best correction or a visual field less than 20 degrees that adversely impacts educational performance and interferes with daily activities (Thomas, Barker, Rubin, & Dahlmann-Noor, 2015). For this study, a video magnifier was defined as an electronic, desktop device that can magnify text and can change the foreground and background colors of text. The type of video magnifier used in this study was a Closed-Circuit Television (CCTV). The video magnifier had a flat, widescreen LCD monitor with a stationary reading tray. An Apple iPad is a tablet device with a touch-sensitive screen, and
that has built-in accessibility features such as magnification and contrast enhancement. For this study, an iPad Pro model with a 10.5-inch screen was used.

**Historical Background of Reading**

The origin of literacy has been dated back thousands of years with written communication documented around 3000 BCE among the Sumerians and Babylonians (UNESCO, 2005). The concept of literacy expanded and evolved from oral communication to the development of writing and reading. As written language was refined over time, access and ability to understand written language and to write was often restricted to members of the nobility, religious leaders, government servants, accountants, traders, or members of specialized guilds (Kaestle, 1985; UNESCO, 2005). This state of affairs endured in most societies (there is evidence that Rome and Byzantium were exceptions) until the 16th or 17th century.

The effects of industrialization and urbanization, mixed with social changes, affected the emphasis on literacy in Europe and America. American culture began to focus on literacy first among free men, then women, and finally children. As early as 1642, parents were obligated to provide religious education to their children in the Massachusetts Bay Colony under The General School Law of 1642 (Essex, 2015). The informal approach to education was family-centered with a typical focus on biblical reading, writing, building moral character, or learning a trade or skill (Essex, 2015). The shift to formal schooling was significantly influenced after the passing of compulsory education laws in the early 1900s. A rise in literacy rates in the United States was an effect of formal schooling (UNESCO, 2005).

With the emergence of formal schooling, literacy became the foundation of the educational system and the primary focus of instruction. The importance of literacy for all children has
been stressed by schools and the government, which invested resources in literacy promotion and research. Therefore, it is necessary to define literacy in modern terms. A comprehensive description of literacy is a “context-bound continuum of reading, writing and numeracy skills acquired and developed through processes of learning and application, in schools and other settings appropriate to youth and adults” (UNESCO, 2006, p. 30). Literacy is a broad term, but this dissertation will address mainly the reading component of literacy with a primary focus on oral reading fluency and comprehension in the school setting.

**Reading in the Twentieth and Twenty-First Century**

In modern American society, advanced literacy skills are becoming essential for post-secondary education and for competing in the skilled labor market (Murnane, Sawhill, & Snow, 2012). Someone with advanced literacy skills would “use reading to gain access to information, synthesize information across different sources, evaluate arguments, and to learn new subjects” (Murnane et al., 2012, p. 5). Reading lies at the core of higher level skill development. The term reading is broad, requiring further explanation. Reading has been defined as “the process of constructing meaning from written texts and as a complex skill requiring coordination of a number of interrelated sources of information” (Anderson & NIE, 1985, p. 7). Reading is a lifelong process. The Commission on Reading stated the importance of reading as being “a cornerstone of a child’s success in school, and indeed, throughout life” (Anderson & NIE, 1985, p. 1).

Federal discussions regarding reading and educational policy became more prevalent during the latter half of the twentieth century with the passing of the Elementary and Secondary Act, the institution of the National Assessment of Educational Progress, the establishment of the Department of Education, and the report from the Commission on Reading in 1983. As the
twentieth century came to a close, the National Reading Panel (NRP) was formulated in 1999 upon Congressional request of the National Institute of Child Health and Human Development (NICHD) to examine the research-based knowledge and evidence-based practices in reading and methods to teach reading. Extensive research into reading and instructional approaches has shown that to become a proficient reader; one needs skills and strategies in phonemic awareness, phonics, fluency, comprehension, and vocabulary (NRP & NICHD, 2000).

**Reading Fluency**

Initially, reading fluency was presumed to be a direct outcome of the ability to automatically recognize words. (NRP & NICHD, 2000). As an illustration, only 16% of 372 commercially available reading tests from the early 1900s to 1999 assessed fluency, and few classroom-based textbooks addressed fluency (Fuchs, Fuchs, & Hosp, 2001). Before the 1970s, the research literature on fluency was scarce. Then in the 1970s, research literature shifted to phonological awareness, the role of automaticity in word recognition, and accuracy in isolated word lists (Fuchs et al., 2001; NRP & NICHD, 2000). However, intervention studies using isolated word lists and word decoding did not always yield large or significant effects (Fuchs et al., 2001). Furthermore, the results from the National Assessment of Educational Progress showed that 44% of fourth graders across the United States were disfluent in grade-level stories (Pinnell et al., 1995). The National Reading Panel report accentuated the importance of expanding the previous conceptualization of fluency past word recognition to reflect the complex process of oral reading fluency.

Oral reading fluency is a multistep, complex process in which a reader efficiently and automatically decodes words, smoothly and accurately reads with prosody and comprehends the
text (Wolf & Katzir-Cohen, 2001). The rate of processing, rapid recognition, and coordination of the processes is key to reading fluency. For a skilled reader, one would “read words accurately, rapidly, and efficiently” (NRP & NICHD, 2000, p. 191). This rapid interpretation by a fluent reader may be done with little conscious attention and demand to the working memory allowing for more space in the working memory to derive meaning from the text (Wolf & Katzir-Cohen, 2001). Conversely, a child with low reading fluency may devote more attention to the word recognition and retrieval process, which may tax the working memory and reduce recall and comprehension (Wolf & Katzir-Cohen, 2001).

Obstacles to Reading Fluency for Students with Visual Impairments

For certain children, there are obstacles to literacy development. Children with visual impairments can have limited or even restricted access to literacy in educational settings. In the United States during the mid-1800s, children with visual impairments and blindness typically attended private schools for the blind or public residential schools for the blind (Holbrook, McCarthy, & Kamei-Hannan, 2017). This experience varied from their sighted peers, who were typically educated in their homes and community. In the 1900s, students were placed in general education classes in public schools without a federal law outlining specific mandates for the education and rights of children with disabilities. Equal access to educational content and materials was not guaranteed for children with visual impairments.

The passing of Public Law 94-142 or the Education for All Handicapped Children Act (EHA) of 1975 placed detailed provisions for the education of students with disabilities such as access to free and appropriate public education, comprehensive assessment, development of an Individualized Education Plan (IEP), and due process (EHA, 1975). The Education for All
Handicapped Children Act permitted school districts to formally assess and identify the individual needs of students with disabilities, and to create a plan to provide services and accommodations. The EHA of 1975 did not have specific language regarding the use of assistive technology devices for educational purposes in the IEP, but the Individuals with Disabilities Education Act of 2000 added language regarding the use of assistive technology devices to the IEP.

Even with legislative changes that increased educational accessibility, an issue remained regarding children with visual impairments having equal access to textbooks and instructional materials. Not all textbooks and instructional materials were accessible to children with visual impairments, especially for students who needed to access materials in an alternate reading medium. The Individuals with Disabilities Education Improvement Act (IDEA) of 2004 indicated that instructional materials needed to be accessible and delivered in a timely manner (IDEA, 2004). Educational media services established the National Instructional Materials Accessibility Act (NIMAS) to provide electronic source files of textbooks and the National Instructional Materials Access Center (NIMAC) to be the electronic file repository (Holbrook et al., 2017). The creation of NIMAS and NIMAC has increased access to educational materials and literacy for children with print disabilities, but many materials are not produced well and are given late to students (Holbrook et al., 2017).

In addition to access issues for educational materials, the physical process of reading can pose a significant difficulty and challenge for children with visual impairments (Smallfield, Clem, & Meyers, 2013). Children with visual impairments often read print more slowly and less accurately than sighted peers (Bosman, Gompel, Vervloed, & Van Bon, 2006; Corn et al., 2002; Douglas, Grimley, McLinden, & Watson, 2002; Gompel, Van Bon, & Schreuder, 2004). When reading text materials, children with low vision may have a decreased reading rate due to the
additional visual motor processes (Gompel et al., 2004). The rapid succession of eye movement along a line (saccades) and fixation are crucial to reading fluency and gathering information from the text (Bosman et al., 2006). Children with ocular motor conditions such as nystagmus may have difficulty with maintaining smooth and efficient eye movements across multiple lines of text. In addition to ocular conditions, Legge, Rubin, Pelli, and Schleske (1985) found that reading rates for participants with retinal disorders affecting the macula and resulting in a central field loss were slower than participants with intact central fields. Another factor contributing to reduced reading speed was whether a reader had clear or cloudy ocular media. Decreased reading rates can also occur among individuals with visual field restrictions, which can affect saccades and fixations (Bosman et al., 2006). Thus, the type of visual impairment may have specific, functional implications on the visual skills necessary for reading.

Another challenge to reading and literacy for children with low vision is the print size (Alabdulkader & Leat, 2009). "The size of print can affect the efficiency with which the visual system can perform the task" (Bailey et al., 2003, p. 327). If the print is either too small or too large, the print size may decrease reading rates. Small print size might be difficult to see while large print text limits the amount of text a reader can view on a page or screen, which may lead to slower reading rates. For students who struggle to read standard print, the use of large print text or low vision devices can be crucial for reading. Enlargement of print is not only achieved by physically making the print larger, but also by the use of optical devices that magnify print.

**Providing Access to Print for Students with Visual Impairment**

Assistive technology for students with low vision often includes optical aids such as spectacle mounted device systems and handheld magnifiers. Students may also use electronic
video magnifiers such as a CCTV (closed circuit television) or an iPad to read print materials. Lussenhop and Corn (2002) reviewed eight quantitative studies conducted over a period of 30 years regarding the reading performance of students with visual impairments when using large print and optical aids. Students using optical aids significantly increased silent reading comprehension but not oral reading comprehension. However, three studies found no significant difference between oral reading rate with large print and with optical devices and standard print.

Corn et al. (2002) conducted a research study called Project PAVE (Providing Access to the Visual Environment) to examine the impact of optical aids and training on silent and oral reading rates and comprehension. Approximately 70% of the participants received optical magnifiers and monoculars. Statistical significance was reported in the improvement of silent reading speed and comprehension rates among the participants but not in oral reading speed and comprehension rates. Of note, students in grades one through three significantly increased silent reading comprehension, which is consistent with the literature regarding the growth of oral reading fluency during primary grades (Fuchs et al., 2001). The mentioned studies focused on the use of optical aids versus electronic devices.

Two more recent studies focused on oral reading and low vision devices for children with visual impairments. Douglas, Kellami, Long, and Hodgetts (2001) used a repeated-measures experimental research design to compare children with visual impairments reading from paper versus from a computer screen. The Neale Analysis of Reading Ability (NARA) was used to evaluate reading speeds and fluency errors. No statistically significant differences existed between the groups; however, within-participant differences showed faster reading rates on the paper passages. Next, Lusk (2012) used a single-subject study to explore the effects of different mounting systems of prescribed near magnification devices on reading performance and preference in five
school-age students with low vision. Lusk (2012) compared oral reading rates and fluency on curriculum-based measurement passages across four mounting systems: handheld, stand-mounted, spectacle-mounted, and a portable video magnifier. The raw reading rates varied across each magnification system among each participant. For student D, reading speed was the highest when using a spectacle-mounted magnifier. Student A had higher speeds with spectacle-mounted magnifiers for three sessions, handheld magnifier for two sessions, and standard correction and print for one session. Student M performed at the highest reading speed with standard correction and print, handheld magnifier, and spectacle-mounted magnifiers. When her vision was stable, student K’s highest reading speeds were stable with the stand-mounted magnifier. Lastly, student L had three high reading speeds with standard correction with standard print but demonstrated an increase in reading speed with the stand-mounted magnifier over the six sessions.

Research within the past five years has been conducted on the use of an iPad or electronic video magnifiers but among adults with low vision. A study conducted by Riley, Johnson, and Wittich (2016) examined iPad and CCTV reading performance using the International Reading Speed Text (IReST) for 25 adults with low vision with a mean age of 56 years. The results showed no statistically significant differences between the iPad and CCTV, but 72% of participants preferred reading on the iPad. However, a comparison between an eReader, iPad, and standard print among 27 adults with macular degeneration with a mean age of 78.9 years found faster reading speeds on the iPad than paper or the eReader, for text sizes of 24 point or greater (Gill, Mao, Powell, & Sheidow, 2013). The results may provide insight into reading performance and preference of reading devices among students with low vision. However, caution should be taken when generalizing these results to children with low vision due to age, the development path of oral reading fluency, and experiences with print materials.
Significance of the Research

There is limited evidence comparing the use of assistive technology devices and large print text among children with low vision on oral reading outcomes (Thomas et al., 2015). Where assistive technology has been evaluated, there is a gap in the current literature on the use of iPads for reading among children. This study has the potential to contribute to general knowledge on the use of reading media (iPad, video magnifier, and large print text) and oral reading outcomes for children with low vision. Low vision can significantly impact access to print materials and reading ability. The results may provide insight into whether a change is evident when using different reading media. The study results seek to substantiate the need for conducting a Learning Media Assessment and analyzing the reading outcomes with large print, optical devices, and electronic magnifiers for students with low vision. It may provide insight and guidance in selecting reading tools and devices for children with low vision, which would relate to Sensory Efficiency and Assistive Technology skills in the Expanded Core Curriculum. Furthermore, students may benefit from the knowledge of what reading tools and devices may be more effective for reading print materials.

Statement of the Problem

Aside from standard optometric correction, large print text was the primary adaptation to standard print for students with low vision before the introduction of optical devices. As technology developed, electronic video magnifiers allowed a user to change the settings and magnification level to accommodate individual needs and preferences. More recently, Apple iPads have become a staple in educational settings. The portability, apps and standard built-in accessibility features that allow the user to modify the settings to accommodate the user’s visual
needs attribute to the appeal and use among students with visual impairments. Given the new technology and range of low vision devices available to students, this study sought to examine the use of the iPad, video magnifier, and large print text during oral reading passages and establish whether oral reading outcomes differ for the different reading conditions.

The study employed a single-case research design to investigate the use of an iPad, video magnifier, and large print text on oral reading rate, fluency, and comprehension among children with low vision. Single-case research allows a researcher to examine the individual participant and the participants as a whole through a visual analysis of the pretest, intermediate, and posttest data points. The study also sought to identify the types of oral reading fluency errors made by children with low vision, which may be attributed to specific eye conditions.

**Chapter Summary**

Formal education is based on reading ability and competence. Reading ability has been linked to educational success. The National Reading Panel emphasizes the importance of reading fluency and comprehension as part of the five skills necessary for proficient reading. In educational settings, the physical process of reading may be challenging for children with visual impairments. Also, children with low vision may experience difficulties with reading standard print materials and have reading rates below their peers. To access text, students with low vision can use large print, low vision devices, or a combination. The evolution of technology has yielded additional options for enhancing children’s reading of text materials. A gap in the literature exists in how well children with low vision read text when using an iPad, a video magnifier, or large print text. This dissertation paper explores the relationship of using an iPad, a video magnifier, and large print text on oral reading outcomes for children with low vision.
CHAPTER II

LITERATURE REVIEW

Origin of Literacy

Literacy evolved from oral to written culture over millennia with the evolution including prehistoric cave drawings and symbols to written communication documented among Sumerians and Babylonians around 3000 BCE to the invention of consonants, vowels, and punctuation to modern day print and technology. Literacy has involved reading or the interpretation of symbols and the ability to create and write symbols in a meaningful manner. Underlying reading and writing skills is the social context of literacy, which has dictated the importance of reading and writing skills throughout the ages. Plainly stated, literacy is a culturally dependent construct (Johnson, 2015).

Oral language and communication are at the foundation of literacy. The ability to read evolved from written expression. Over the ages, text was written on clay tablets, papyrus scrolls, wood tablets, and animal skins (Johnson, 2015). For much of history, production of written works was tedious and time-consuming, which made access and availability of print texts limited. The invention of the printing press around 1450 CE revolutionized text production and altered how information was circulated (Dittmar, 2011). However, literacy and formal education were generally restricted to the elite including nobility, clergy, public administration, craftsmen, and traders for centuries (Craig, 1981; Kaestle, Damon-Moore, Stedman, Tinsley, & Trollinger, 1991). Access to literacy was based upon social status, which unintentionally created a social
divide and bias. For those with access to print materials, the ability to read and write had economic implications, particularly in commerce. Dittmar (2011) stated that print assisted in the “development of numeracy, emergence of business education, and the adoption of innovations in bookkeeping and accounting” (p. 1134).

Between the years 1607 to 1840, religious and patriotic views profoundly influenced reading instruction (Vogt & Shearer, 2003). In colonial America, literacy rates were high, but the measurement of literacy was challenging. Before the 1850s, literacy was associated with signing one’s name and reading essential documents such as wills, deeds, and marriage registers (Grubb, 1990; Kaestle et al., 1991). This type of literacy was rudimentary. Informal education was provided in the home environment. Reading and writing content was related to biblical text and trade skills and were taught and reinforced by family (Essex, 2015). Also, instruction focused on the alphabet, spelling, oral reading, and recitation of Bible verses (Vogt & Shearer, 2003). During the Colonial period, increased literacy may be attributed to the efforts of Protestantism and the Puritans through religious education (Kaestle et al., 1991). Colonial schools typically focused on religious education and moral character.

In 1635, the Latin Grammar School in Boston became the first public secondary school, but public education was not emphasized until after the American Revolution (Thattai, 2001). The creation of a united nation sparked the use of education as a tool for citizenship and maintaining the democratic process. Jefferson stated, “an enlightened citizenry is indispensable for the proper functioning of a republic” (Thomas Jefferson Foundation, n.d.). Thomas Jefferson was a proponent of the establishment of elementary and secondary schools. He stated to Peter Carr in 1814, “It is highly interesting to our country, and it is the duty of its functionaries, to provide that
every citizen in it should receive an education proportioned to the condition and pursuits of his life” (Encyclopedia Virginia, 2018).

Governmental policy facilitated the enactment of public education. At the federal level, Act 3 of the Northwest Ordinance of 1787 granted land for public universities creating land grant universities (EPI, 2011). For primary education, individual colonies or states enacted compulsory education laws. Massachusetts Bay Colony was progressive and the first to pass compulsory education laws in 1642. By the end of the 1800s, 34 states had compulsory school laws, and by 1918, all states had compulsory education laws. The shift to formalized schooling influenced the evolution of literacy beyond signature literacy and religious instruction for children and adults in the United States. As printed materials became readily available, people increased the desire to acquire new knowledge and to be involved with the community and politics. The rise in literacy affected economic development by increasing the need for educated and literate people (Kirsch & Guthrie, 1977). Proficiency in reading and writing skills became a primary goal of formalized education. After World War I, schools began to emphasize reading for information rather than reading for religious purposes. Due to soldiers’ difficulty in reading technical and instructional manuals during World War II, schools made reading expository and informational texts a priority in reading instruction (Vogt & Shearer, 2003). Systematic reading instruction focused on decoding, and phonemic awareness was the primary approach used until the 1960s when instruction shifted to the linguistic approach. Reading instruction before the 1980s had little focus on comprehension and oral reading fluency. The 21st century marked significant changes in educational methods and perspectives towards reading instruction.
Purpose and Definition of Reading

When one has access to information, one can learn and grow intellectually (Johnson, 2015). Reading is a communication tool. When viewing written text, the rate of input can be regulated by the reader (Just & Carpenter, 1980). Johnson (2015) stated, “Reading extends human oral communication” allowing people “to access information and participate in culture” (p. 113). Reading is a dynamic process involving “transmission” of the words to the reader, “interaction” between the reader and text, and “transaction” of meaning by the reader (Binkley & Williams, 1996). Whether reading is for memorization or leisure, the purpose plays a vital role in the process. “The reader’s goals are perhaps the most important determinant of the reading process” (Just & Carpenter, 1980, p. 350). The goals for reading vary depending upon the individual, type of text, and purpose for reading (Just & Carpenter, 1980). Practical or functional literacy examples for adults and children outside of school include reading a property deed, business ledgers, transit signs and schedules, and trade manuals. In schools, instruction in literacy skills is referred to as reading achievement (Kaestle et al., 1991). Reading achievement has been defined and reported in the National Reading Panel Report in 2000. From the National Reading Panel report, one needs skills and strategies in phonemic awareness, phonics, fluency, comprehension, and vocabulary to be a proficient reader (NICHD, 2000).

Defining reading is necessary to understand it in the context of modern education. Reading is “the process of constructing meaning from written texts and as a complex skill requiring coordination of a number of interrelated sources of information” (Anderson & NIE, 1985, p.7). A simplified equation of the reading process can be written as: information from text + knowledge from reader = meaning. There are five primary generalizations about skilled readers from previous research on reading. The first generalizations are that reading “is a
constructive process, must be fluent, must be strategic, requires motivation, and is a continuously developing skill” (Anderson & NIE, 1985, p. 17). Secondly, skilled readers activate existing knowledge to make connections and derive meaning. The third generalization proposes that to be fluent, a skilled reader must have automatic and accurate word decoding. Strategic reading refers to the reader’s flexibility in response to the different purposes of reading, the difficulty of texts, and knowledge of various subjects. Lastly, reading is a lifelong skill requiring a considerable amount of practice.

Physical Aspects of Reading

Reading is an intricate process of subskills that are integrated together to perform the task (Anderson & NIE, 1985). The reading process can be broken into aspects. The first aspect of the reading process involves a reader’s eyes and eye movements. Bilateral coordination of the eyes and eye muscles is a fundamental function in the reading process (Demilia, 1968). Just and Carpenter (1980) provided a framework detailing the processes and structures of reading. The first stage requires the eyes and the brain to “find information, encode it, and process it” (Just & Carpenter, 1980, p. 336). The visual process of reading consists of four eye movement components: fixation phases, saccadic movements, regressive saccades, and return sweeps.

Fixation phases occur when the eye makes stops during print reading. During fixation phases, the number of letters or words seen is called visual span or recognition field and lasts about 200-300ms (Bailey et al., 2003; Dickinson & Fotinakis, 2000). The text is identified, processed, and integrated with previous fixations in the fixation phase. The perception of words during the fixation phase is cued by individual letters, small letter groups, and word shape or
form (Demilia, 1968). The fixation phases constitute approximately 93% to 95% of the total reading time (Demilia, 1968).

To locate the next information in a line, the eyes move rightward from one fixation pause to another across lines of text. The rapid, succession of eye movements is called saccades (Bailey et al., 2003; Demilia, 1968; Spichtig, Pascoe, Ferrara, & Vorstius, 2017). Saccadic movement transfers text into the fovea, the retinal area with maximum visual acuity and detail (Rayner, 1978). Rayner (1978) reported that the average saccade is eight character spaces or about two degrees of a visual angle, but that saccade lengths can vary among individuals within a passage. Saccades account for only five to 10% of total reading time (Just & Carpenter, 1980).

In addition to forward saccadic eye movements, eyes make regressive saccades going from right to left to reread a word or group of words. The fourth component is the return sweep. The return sweep occurs when the eyes move from the last word in a line to the first word in the next line. Interestingly, the return sweep may not land on the first word and a corrective saccade may be made due to inaccurate targeting by a reader’s peripheral vision (Just & Carpenter, 1980). G. T. Buswell concluded that oculomotor patterns stabilized by the end of fourth grade (as cited by Demilia, 1968). These four eye movements have been related to reading proficiency. Skilled readers tend to make fewer regressions and fixations and read faster than poor readers (Demilia, 1968; Spichtig et al., 2017). Smith concluded, “Skilled readers average about 90 fixations for 100 words” (as cited by Bailey et al., 2003, p. 327).

When reading, light energy is transmitted onto the retina in the foveal, parafoveal, and peripheral regions. The foveal region spans one to two degrees around the fixation point, the parafoveal region spans 10 degrees around the fixation point, and the peripheral region includes the area on a line outside the parafoveal region (Rayner, 1978). Visual acuity is reduced when
the parafoveal and the peripheral regions are used, but those regions may assist in steering eye movements to the next fixation point and in gathering information within the perceptual span.

**Legibility and Readability of Text**

The second physical aspect of reading is the legibility of the text. “Legibility is related to the capability of a text to be identified properly, and it is related to the ease of eyes to detect words and letters, which is important for data acquisition in reading” (Tarasov, Sergeev, & Filimonov, 2015, p. 1301). Legibility refers back to visual design and appearance of print materials and “is a function of clarity of design” (Demilia, 1968, p. 16). The physical appearance of the text is the first point of contact the reader has with text (Tarasov et al., 2015). Text communicates to the reader, and subsequently, the readers’ interaction can be affected by the visual presentation. Numerous aspects attribute to the legibility of print. These components include the paper and ink of the printed page, typeface or the design of the type used, spacing within the text, line length, and layout and physical format of elements on a page (Bloodsworth, 1993; Demilia, 1968).

The terms readability and legibility have been used in research when examining the effects of texts on reading. Readability expands upon legibility and includes: reading speed, recognizability threshold distance, volume of perception, threshold of focus, fatigue, number of fixations, number of returns, eye movement regularity, rhythm of reading, reading ability factor, specific readability, height of letters, height of signs, subjective judgements of readers and aesthetic judgments of readers (as cited by Tarasov & Sergeeva, 2013). The criteria examine the visual aspects of reading (eye movements) about the physical appearance of the text and experiences of the readers. Readability of text can be demonstrated by a comparison of the text read (fluency) and the comprehension level of the text (Tarasov & Sergeeva, 2013). Given the
expansiveness of readability, the emphasis will be placed upon legibility of text and potential impact on eye movements and reading for children with low vision.

**Typography and Effects on Legibility**

**Materials**

The paper and the ink on the printed page is one factor that may affect legibility. Hackman and Tinker (1957) reported the best legibility to be black text on white paper, black text on yellow paper, red text on white paper, and green text on red paper among college students with typical vision. In a study conducted by Starch, black on white text was read 42% faster than white print on a dark gray background (as cited by Demilia, 1968). For maximum legibility, one should have maximum brightness contrast between the print and background paper (Hackman & Tinker, 1957).

**Spacing**

Spacing is also known as leading. Leading refers to the amount of space between lines and is measured in points (Bloodsworth, 1993; Demilia, 1968). Line spacing is determined by the distance between the baselines of the text (Tarasov & Sergeeva, 2013). The baseline is an imaginary horizontal line upon which characters or a line rests. Print material without leading (or set solid) is read more slowly than text with leading (Demelia, 1968; Mills & Weldon, 1987; Tinker, 1965). Kolers, Duchnicky, and Ferguson (1981) reported fewer fixations per line and words read per span and a slightly longer reading speed with single-spaced text on a computer (CRT) display. Individuals with typical vision had a minor reduction in fixations and slightly faster reading rates with double-spaced text. Tinker and Paterson found two points leading for
the 10-point type with a 19 pica line width enhanced legibility by over 5% (Bloodsworth, 1993). Tinker also recommended more leading for children in elementary grades. An additional spacing technique in typography is called kerning, which adjusts space between two letters or characters to increase legibility (Bailey et al., 2003). Kerning can reduce gaps between letters or characters by placing the letters in the same vertical plane (Connolly, 1998). For example, the letters VA are displayed without kerning, and with kerning, the letters display as VA. However, the spacing is only one aspect that contributes to legibility. Tinker (1965) reported that the spacing depends upon the typeface, type size, and line length.

**Line Length or Width**

The number of characters per line of text can vary depending upon the typeface size and page format. The standard measure of line length is a pica, which is approximately one sixth of an inch (Demelia, 1968). When presented with short lines in 10-point type, a reader has more fixation pauses of longer lengths and more return sweeps (Paterson & Tinker, 1940). Paterson and Tinker reported a difference in eye movements for long lines of text. They stated that longer lines could make executing an accurate return sweep difficult for readers. To accommodate for longer line lengths, one should add more space between lines to allow the eyes to complete the return sweep (Tinker, 1965). Based upon the average reader, one has a visual span of three to four words or 12 to 15 picas wide and has better comprehension with two fixations per line, making the ideal length seven or eight words with approximately 45 to 55 characters per line (Bloodsworth, 1993).
Page Format

Page layouts differ between media formats: newspapers, magazines, textbooks, chapter books, and web-based text. Newspapers and magazines tend to apply a multi-column design and use shorter line lengths. Tarasov et al. (2015) discussed the variance in research results on column formats ranging from inconclusive results and no significant differences between multi-column and single-column reading rates among adults. Slightly faster reading rates were reported with a single column layout and long lines, while others reported faster reading rates with a multi-column format and slower reading rates with single-column layout among adults. Narrow margins in children’s books can elicit visual fatigue (Bloodworth, 1993; Demelia, 1968).

Line justification is an additional factor to consider with page format. The purpose of justification is for text clarity and uniformity (Demeila, 1968). Justification may affect the spacing between letters, words, and sentences. Text without justification or justification with variable character spacing has been reported to generate faster reading rates, but additional evidence is needed in the use of justified lines on reading rates (Mills & Weldon, 1987).

Type Face

Type face entails the style or design of the type, size, and elements such as bold, italics, and capitals. “All characters within a single type face are called a font” (Demelia, 1968, p. 24). The styles can be categorized into serif fonts and sans serif fonts. Serif fonts have distinct details or embellishments at the end of characters, and sans serif fonts are without the embellishments. Times New Roman is a serif font frequently used in novels and textbooks, and Arial is a common sans serif font. Typography literature has suggested that serifs may assist readers with discriminating letters, increase the visibility of the ends of strokes, and possibly enhance the reader’s
ability to track across the line (Arditi & Cho, 2005). Legibility of font has been investigated primarily with adults. However, Paterson and Tinker (1940) stated that children in fifth grade and above have similar responses to adults when presented with various typefaces. They also recommended moderately dark typeface for children’s books.

The second element of typefaces is the width of the characters. Fonts may be fixed-width (monospaced) or variable-width (proportional) fonts. All characters in a fixed-width font occupy the equal amount of space, and characters in a variable-width font occupy different amounts of space (Mansfield, Legge, & Bane, 1996). Examples of fixed-width fonts are Courier New and Lucida Console, and variable-width fonts are Times New Roman and Arial. Arditi, Knoblauch, and Grunwald (1990) examined fixed-with fonts and variable-width fonts on reading speed among adults with the typical vision of 20/20 or better in both eyes with or without correction. A fixed-width font yielded faster reading rates with smaller print at the critical reading size, but a variable-width font yielded faster reading rates with medium to large print due to a crowding effect (Russell-Minda et al., 2007, cited in Arditi et al., 1990).

**Type Size**

Font size has been a topic debated among researchers. The majority of publishers use a 10 to 11 point font (Bloodsworth, 1993; Tarasov et al., 2015). For children’s books, Burt (1959) reported the ideal size type for children under seven years is 24 points, for children seven to eight years it is 18 points, and the ideal size then decreases by two points until age 10 to 11 (as cited by Bloodsworth, 1993). After age 12, the ideal type size is 11 points, which aligns with Tinker and Paterson’s findings (Paterson & Tinker, 1940). Based upon research results on reading rate tests for children with normal vision, Paterson and Tinker (1940) recommended 14 to 18 point
type for grade one, 14 to 16 point for grade two, 12 to 14 point type for grade three and four, and 11 point type for grades five and above. Tinker (1965) stated that smaller print leads to an increase in fixations, slower saccades, and longer fixation pauses, resulting in slower reading speed. Conversely, a larger print size may increase the number of fixations and may reduce the number of characters perceived in the visual span (Bosman et al., 2006).

The aspects of print legibility discussed are results based on a broad scope of individuals with typical vision. Preferences for spacing, size, type face, and reading distance may vary given the task and vary among individuals. Specific eye conditions or diseases may affect the physical aspect of reading for children.

**Physiological Obstacles to Reading**

**Ocular Disorders**

Several factors impact visual efficiency during the reading process for children with vision issues. The first obstacle is physiological. Numerous visual conditions and disorders may affect one’s ability to read print. The most common ocular disorders among children are refractive errors due to hyperopia or farsightedness, myopia or nearsightedness, or astigmatism, which is an uneven corneal surface (Holbrook et al., 2017). Hyperopia is more prevalent among young children since their smaller eyes affect the ability of light energy to be accurately focused on the retina or foveal region. A child with hyperopia may experience difficulty with near reading and reading for extended periods but may not have trouble with distance vision. It may cause a child to struggle with reading text and to become fatigued. Refractive errors may be corrected with prescription eyeglasses, prescription contact lenses or in some cases, surgical intervention.
Next, ocular motility and muscle disorders may impact the physical aspect of reading. One ocular muscle condition is strabismus, which is misalignment or deviation of an eye or eyes. Strabismus may be present in one or both eyes and cause the eye or eyes to turn out, in, or upward. The deviations are classified as tropias or phorias. Tropias occur when “the alignment of the eyes cannot be controlled” and can be intermittent (Corn & Koenig, 1996, p. 89). Phorias “are tendencies for the eyes to deviate, controlled by the brain’s efforts to achieve binocular vision” (Corn & Koenig, 1996, p. 91). Since the brain receives images from each eye, the misalignment may cause the images to be incongruent thus double vision or diplopia may result (Corn & Erin, 2010). To compensate, a child may cover or close an eye and exhibit a head turn. Strabismus may be treated with occlusion by patching or medication, corrective lenses, or ocular muscle surgery. Early diagnosis and treatment are crucial. However, if the deviation goes undetected or untreated, vision loss and a reduction in visual acuity called amblyopia (lazy eye) may occur (Holbrook et al., 2017). Amblyopia occurs when the brain has suppressed vision from an eye with a deviation, or an eye that is weaker.

Another ocular muscle disorder affecting reading is nystagmus. Nystagmus involves involuntary eye movement either in a horizontal, vertical, or pendular motion in one or both eyes (Corn & Koenig, 1996). Images appear stationary even when the eyes are moving. The movement causes a reduction in visual acuity. Nystagmus may cause a child to lose a place on a line or to expend more energy to focus on the text (Holbrook et al., 2017).

**Low Vision**

Ocular disorders and refractive errors may cause vision difficulties but not low vision. For individuals with reduced visual acuity, the term low vision was used to describe the variation
in vision between sighted and blind (Legge, 2016). An expanded definition of low vision is “a person who has difficulty accomplishing visual tasks, even with prescribed corrective lenses, but who can enhance his or her ability to accomplish these tasks with the use of compensatory visual strategies, low vision and other devices, and environmental modifications” (Corn & Koenig, 1996, p. 4). In the past, the inability to read newsprint with the best correction at a standard near distance of 16 in. has been used to functionally define low vision (Legge, 2016). Low vision has been defined by the World Health Organization as visual acuity of 6/18 (20/63) or less in the better eye with the best correction or a visual field less than 10 degrees from the point of fixation (WHO, 2018).

Diseases and conditions can also occur in the following parts of the visual system: cornea, iris, lens, vitreous, retina, as well as in the cerebral cortex (Corn & Koenig, 1996). A visual impairment in any of these areas may impact reading. Common eye conditions among children with visual impairments in the United States involve the cerebral region, optic nerve, and retina. Retinal diseases or conditions affect the light energy coming to the posterior chamber of the eye. Damage to the optic nerve, visual pathways, and visual cortex impact the ability of the brain to process visual information such as text and images.

**Prevalence of Visual Impairments**

The prevalence of visual impairments among children in the United States has been documented by the American Printing House for the Blind, the American Community Survey, and the U.S. Department of Education in conjunction with the Office for Special Education and Rehabilitative Services and the Office of Special Education Programs. According to the U.S. Department of Education, Office for Special Education and Rehabilitative Services, and Office
of Special Education Programs (2017), there were “6,050,725 students ages 6 through 21 served under IDEA, Part B, in the 50 states, the District of Columbia, BIE schools, Puerto Rico, the four outlying areas, and the three freely associated states” in 2015 (p. 26). Students with a primary educational category of visual impairment comprised 0.4% or approximately 24,202 children. To receive special education services under IDEA in the visual impairment disability category, a child must have “an impairment in vision that, even with correction, adversely affects a child’s educational performance” (IDEA, 2004). Individuals with Disabilities Education Act does not define a visual acuity requirement for students to receive educational services such as a best corrected distant or near acuity of 20/70 or a field loss of 20 degrees or less. However, many states had provisions regarding qualifying best corrected visual acuity and degree of peripheral field loss. Furthermore, the number of students with visual impairments recorded may be affected by the use of a primary educational label in reporting statistics, since states are required to report one classification (Holbrook et al., 2017). An additional factor contributing to lower numbers of children reported with a visual impairment is the prevalence of an additional disability among student with visual impairments, which has been estimated to be around 65% (Dote-Kwan, Chen, & Hughes, 2001; Mervis, Boyle, & Yeargin-Allsopp, 2002).

The American Printing House for the Blind (APH), the largest nonprofit organization providing resources and materials for individuals with visual impairments, manages Federal Quota funds to be used for educational materials for students enrolled in an educational program (APH, 2018). Through the annual registration of eligible students meeting the definition of blindness or functions at the definition of blindness, APH reported 63,501 eligible students at schools for the blind, state departments of education, programs for students with multiple disabilities, and rehabilitation programs (APH, 2018). This reported number may not reflect the individuals are
meeting the WHO definition of low vision. The third source of prevalence statistics regarding children with visual impairments is the American Community Survey (ACS). From the 2016 1-Year Estimates, ACS reported that approximately 571,800 children under 18 years of age have vision difficulty and disability in the United States (U.S. Census Bureau, 2016).

**Obstacles to Reading for Children with Low Vision**

**Ocular Conditions**

Children with low vision may have slower reading speeds due to longer fixations and shorter saccades (Bosman et al., 2006). Bailey et al. (2003) noted that for children with low vision, the “ratio of letters per fixation may be reduced, the average pause time for each fixation may be longer, or there may be more frequent regressive saccades” (p. 327). The type of visual impairment may also affect the physical process of near reading. High myopia and hyperopia may affect fixation and the number of regressions used when viewing print. Reduced visual acuities can impact a child’s ability to efficiently identify letters and words in lines of text (Bosman et al., 2006; Gompel et al., 2004).

**Peripheral Field Loss**

Peripheral field restrictions may impact a reader’s ability to view and identify words or symbols within the visual span and perform a return sweep (Gompel et al., 2004). A reader with significant peripheral field restriction may have difficulty with recognizing characters in longer words and may need to execute further fixations to identify all the characters (Bosman et al., 2006; Gompel et al., 2004). Legge et al. (1985) concluded that reading slowed among adult participants with low vision with a visual field narrower than four character spaces.
Central Field Loss

Central vision loss can impact fixation, saccades, visual span, and regressions. Stargardt’s is a macular disease affecting central vision in children; in adults, it is identified as macular degeneration. The diseases can cause unilateral or bilateral central field loss or scotomas, areas with reduced or no acuity (Bosman et al., 2006). Central field scotomas or damage to the macular region impacts a reader’s ability to fixate upon text and causes the reader to use peripheral regions of the retina for reading (Bosman et al., 2006). If one cannot use the foveal area of the retina for fixation, a reader may use an eccentric part of the retina. This adaptive strategy is known as preferred retinal locus. Preferred retinal locus (PRL) has been defined as “One or more circumscribed regions of functioning retina, repeatedly aligned with a visual target for a specified task, that may also be used for attentional deployment and as the oculomotor reference” (Crossland, Engel, & Legge, 2011, p. 2112). The unconscious and repeated use of PRL among individuals with macular degeneration or Stargardt’s led to faster reading speeds than in individuals consciously aware of using an adaptive fixation and who had less experience (Crossland et al., 2011). Central field loss accounted for 64% of the variance in reading speed among individuals with low vision (Legge et al., 1985). The presence of central field loss may be a factor in reading speed, but the size and shape of scotomas may be a contributing factor to variability in reading speed among individuals with central-field loss (Legge, Ross, Isenberg, & LaMay, 1992).

Font

The appropriate font types for readers with low vision has yielded mixed results in the literature. The debate is regarding serif and sans serif typefaces. Russell-Minda et al. (2007)
conducted a systematic review regarding the legibility of typefaces for readers with low vision. Among adults with low vision, Arditi & Cho (2005), Arditi (2004), and Moriarty and Scheiner (1984) reported no changes in reading rate between serif and sans serif fonts.

Meanwhile, a study found legibility was best at 14 point sans serif font in black text on a white background for patients with cataracts (Estey et al. (1990) as cited in Russell-Minda et al., 2007). Participants preferred sans serif typeface in studies conducted by Campell, Cutler, McDonald, Putt, Rewak, Strong, and Whitton (2005) and Perea (2001). Mansfield, Legge, and Bane (1996) investigated font effects of sentences read in Times New Roman and Courier-bold for adults with typical vision and low vision. Adults with typical vision had a maximum reading speed of 4.7% faster with Times New Roman than Courier given the participants’ critical print size (Mansfield et al., 1996). Overall, adults with low vision had a maximum reading speed 10% slower with Times New Roman than Courier font. Also of note, the critical print size for adults with low vision was greater with Times New Roman than Courier.

For children with low vision, Uysa and Düger (2012) investigated the effects of training on font type and size preferences by students with low vision. Before the intervention, 32 participants preferred sans serif fonts (Verdana, Arial, Comic Sans, Tahoma), and three participants preferred a serif font (Times New Roman). After the intervention, eight participants preferred Times New Roman, and 27 participants preferred sans serif fonts. All participants self-reported that Tahoma was the least comfortable font type and felt comfortable with all other font types (Uysa & Düger, 2012).
Print Size

The standard print size of educational materials such as textbooks and novels can have a notable effect on reading in children with low vision and reduced visual acuity. Print size is a critical factor that influences reading speed (Virgili et al., 2004). Some people assume enlarging the text is a solution for children with low vision, but enlarging text on a copier to 120% or increasing the font to 18 or 22 points may not be sufficient. Large or magnified text can reduce the number of letters and words fixed in a visual span, which can increase the number of fixations per line (Bosman et al., 2006).

It may be challenging for children with low vision to determine the optimal or critical print size for efficient reading. Solutions for identifying an appropriate print size are intricate and may require individual evaluation or assessment. Lueck et al. (2003) reported the determination of appropriate print size and working distance as a critical factor for reading efficiency for children with low vision. Reading speed for individuals with typical or low vision can be measured by introducing a range of print sizes on near reading cards or charts such as the Bailey-Love Near Reading Card or MNREAD chart to identify a constant reading speed or maximum reading speed, critical reading speed, and reading acuity (Calabrèse et al., 2016).

Critical print size (CPS) is the smallest print size one can read at maximum reading speed (Bailey et al., 2003; Russell-Minda et al., 2007). Reading acuity (RA) or visual threshold is the smallest print size read on the chart or card measured in logMAR notation or Snellen acuity (Calabrèse et al., 2016; Lueck et al., 2003). “Print size corresponding to CPS is typically two times larger than RA” (Virgili et al., 2004, p. 3349). When Lueck et al. (2003) examined print sizes on text reading charts among a small sample of children with low vision, the participants read faster as the print size increased until it approached two to four times the angular size of the
visual threshold. Lueck et al. (2003) recommended the use of print three times the visual reserve for maximum reading efficiency.

Furthermore, the measurement of CPS for individuals with low vision can also specify the minimal level of magnification needed for reading tasks (Russell-Minda et al., 2007). Based on the literature, a connection exists between low vision and measuring reading performance. Fluency is an essential component of measuring reading outcomes among children in schools and will be emphasized.

**Fluency**

Oral reading fluency in a simplified definition is “an oral translation of text with speed and accuracy” (Fuchs et al., 2001, p. 239). During the translation, a reader undergoes a series of complex operations that include word recognition, phonological segmentation, and recoding typically without conscious attention. The processing rate and coordination of print information is a factor in oral reading fluency. Wolf and Katzir-Cohen (2001) reflected the complex processes and further defined oral reading fluency as “a level of accuracy and rate where decoding is relatively effortless; where oral reading is smooth and accurate with correct prosody; and where attention can be allocated to comprehension” (p. 219).

A key factor in fluency is the processing rate of the complex processes. The model of automaticity frequently referenced in literature is from LaBerge and Samuels (1974) (Fuchs et al., 2001; Wolf & Katzir-Cohen, 2001). The bottom-up approach to reading is focused on the development of subskills needed for fluent reading. The subskills are the utilization of visual stimuli or visual features of texts, rapid recognition in lower level skills, and the shift in attention from lower level skills to higher level skills. Similarly, Berninger, Abbott, Billingsley, and Nagy
conceptualized fluency to be impacted by “the rate and persistence of a visual signal or speech signal, the development of phonological, orthographic, and morphological systems, and coordination of responses by the executive functions system” (Wolf & Katzir-Cohen, 2001, p. 219).

Shiffrin and Schneider (1977) added the elements of extensive practice on the acquisition of the automatic processes and the continuation of these processes to completion (as cited by NRP & NICHD, 2000). Those factors may be evident when analyzing growth and improvement in reading rate over a school year or years. The frameworks share a similar assumption that a greater capacity for higher level processing and comprehension of text occurs when word recognition (sublexical processing) is fluent (Fuchs et al., 2001).

For fluency development, there are five primary components: orthographic, phonological, semantic, morphological, and syntactic knowledge systems. Orthographic refers to the visual look of a word or characters, and phonological knowledge relates to the sounds of phonemes or sounds of letters. Morphological knowledge refers to the awareness of word parts (roots, suffixes, and prefixes) and “enhances vocabulary acquisition, fluency, and reading comprehension” (Wolf & Katzir-Cohen, 2001, p. 220). Orthographic, phonological, and morphological processes are related to word recognition. Semantic knowledge relates to the meaning of words, phrases, and sentences, and syntactic knowledge refers to the structure of sentences (Chomsky & Lightfoot, 2002). The processes interact with each other to facilitate fluency and comprehension. “Thus, measurement of oral reading fluency may serve a strong indicator of overall reading competence because it captures individual differences in a number of reading subcomponents at lower and higher levels of processing” (Fuchs et al., 2001, p. 247).
Oral Reading Measurement

Oral reading fluency has the most considerable growth during the primary grades (Fuchs et al., 2001). Assessment of oral reading fluency (ORF) is essential to determine a child’s reading performance. A widely-used assessment method is curriculum-based measurement (CBM). A CBM is an unpracticed passage read aloud by a student for one minute then is scored. The total number of words read per minute (wpm) is calculated then the number of errors is subtracted to obtain the number of correctly read words per minute (wcpm) (Hasbrouck & Tindal, 2006). Qualitative examples of errors during ORF are mispronunciations, substitutions of a different word said than target word, omissions of the target word or lines skipped, insertions, reversals, and words not read or given words. The error rate of a passage is calculated by dividing the number of errors by time read in seconds and multiplying by 60 (Layton & Koenig, 1998).

Curriculum-based measurement allows educators to identify individual performance levels and compare the scores to peers, to conduct repeated measures over time, and to analyze qualitative oral reading behaviors (Fuchs et al., 2001). Based upon ORF assessments, educators may create instructional goals and objectives, determine appropriate reading groups for students, monitor progress, adjust instruction, and use data for screening and eligibility for specialized programs or instruction (Hasbrouck & Tindal, 1992). Additional factors to consider when administering oral reading assessments are the prose difficulty of the text, the instructional level of the child, and the type of text given such as narrative or expository. Johns (2008) recommended for educators to determine the student’s instructional, independent, and frustration level and to assess a student with narrative and expository text.
Dysfluency

Struggling readers may make either longer or shorter forward saccades, may skip words, or make more regressions (NRP & NICHD, 2000). Students with reading difficulties may have phonological deficits, naming-speed deficits, or a combination of both that may increase the processing time of text and affect reading outcomes (Wolf, Bowers, & Biddle, 2000). Furthermore, there may be delays or difficulties with coordinating and integrating information during the reading process. Meyer and Felton (1999) categorized the potential areas of dysfluency as a breakdown in the lower level processes such as the visio-spatial, phonological, or working memory processes, deficits with making relationships between words, meaning, and ideas, and difficulty in prosody and syntax (Wolf & Katzir-Cohen, 2001). The lower level efficiency of word recognition could lead to more focus on higher level demands by taxing the working memory, which can affect recall and comprehension. Dysfluent readers may draw on context clues and prior contextual knowledge for words to aid in word recognition (Fuchs et al., 2001).

Fluency in Children with Low Vision

Children with low vision may read slower than sighted peers of the same age (Corn et al., 2002). Children with low vision may have slower reading rates, accuracy scores, and comprehension levels than sighted peers of the same age (Douglas, Grimley, Hill, Long, & Tobin, 2002). Lueck et al. (2003) found slower average reading speeds for children with low vision than sighted fourth grade peers. As all children got older, the differences in reading outcomes continued to increase for children with low vision.

One factor that may influence reading rates is the presentation of the print either in a text-reading (sentence) or word chart. Lueck et al. (2003) reported that all participants read at a faster
rate on text charts than word charts. The difference reached statistical significance for four participants, who read 1.6 times faster on text charts than word charts (Lueck et al., 2003). Meanwhile, Gompel et al. (2004) revealed that all children read at a faster rate on an isolated word-decoding test than a cloze text-reading task of choosing the appropriate word from three choices. For the cloze text-reading, children with low vision read significantly fewer words per minute than a group matched on reading ability (Gompel et al., 2004).

Word recognition and decoding is a critical process in reading fluency. Overall, children with low vision had lower decoding scores on a word-decoding test compared to the norm sample of sighted peers of the similar age in grades one to six (Gompel, van Bon, Schreuder, & Adriaansen, 2002). Children with low vision in grades three to six in regular schools had significantly lower word decoding scores than their peers.

Identification of constituent letters of a word and the processing of letter-order information in words may pose challenges to word recognition due to reduced visual acuity or central visual field restrictions (Gompel et al., 2004). Additional time may be needed for children with low vision to identify the letters and to store the letters in working memory to complete the task. Letter-order information processing with a central field restriction may cause letter-order errors due to the increase in regressions (Legge, Ahn, Klitz, & Luebker, 1997). Given word decoding tests, children with visual field restrictions had lower mean z-scores than children without visual field restrictions (Gompel et al., 2002).

Children with low vision may rely on an analogy-based reading strategy, which is taking the knowledge of similar words to apply it to unfamiliar words or nonwords. Students with low vision had a faster response rate and increased accuracy when nonwords were paired with a high frequency neighbor than with a low frequency neighbor, which differed from the sighted peers
and suggested students with low vision use analogy-based reading strategies for unknown words (Gompel et al., 2004). When presented with anagrams, students with low vision experienced more difficulty and higher latency rates and will need additional time to process individual letters within words.

Earlier research on oral reading errors conducted by Corley and Pring comparing children with low vision and sighted peers resulted in a similar performance and reading errors for both groups (Bosman et al., 2006). Children with low vision compared to sighted peers had more substitution errors than mispronunciation errors given an ORF assessment (Douglas et al., 2004). Oral reading behaviors in children with low vision were examined by Bosman et al. (2006) by comparing same age peers with typical vision and peers with the same reading level to see if a qualitative difference existed between the oral reading behaviors. Students with low vision were similar to students of the same age with first-letter naming of words and non-words presented on a computer screen and named the first letter of words quicker than the first letter of non-words (Bosman et al., 2006). When given typical and atypical letter-sound relationships, students with low vision had more errors on the typical and atypical stimuli than the same age students; however, all students had more errors on the typical stimuli than the atypical stimuli. Then, high and low frequency words were examined between the groups with the typical and atypical stimuli. Students with low vision and students of the reading level had a reduced naming rate than students of the same age. Overall, a qualitative difference was indicated when the reading behavior of students with low vision differed from the same age group and same reading level group, and a quantitative difference was indicated when the reading behavior of students with low vision and the same reading level group varied from the same age group (Bosman et al.,
2006). The finding is consistent on the lag in reading rate for children with low vision compared to same age peers with typical vision.

**Comprehension**

The intertwined processes involved in oral reading fluency help prepare and allow the reader to attend and derive meaning from the text, which lies at the core of the reading process. Oral reading and comprehension have a reciprocal relationship. The National Assessment of Educational Progress in Reading reported a positive and significant relationship between oral reading fluency and comprehension (Pinnell et al., 1995). Reading comprehension is a cognitive process that integrates complex skills involving language, sensory perception, memory, and motivation (NRP & NICHD, 2000; Pikulski & Chard, 2005). “Reading is the process of simultaneously extracting and constructing meaning through interaction and involvement with the written language” (Tarasov et al., 2015). The reader’s prior knowledge and experience influences the interpretation of the text and derivation of meaning from the text.

**Factors Affecting Comprehension**

The types of texts may influence reading comprehension. Students in fourth and fifth grade had a higher comprehension scores with narrative texts than informative texts (Sahin, 2013). Cognitive ability, native language, and the presence of additional disabilities can impact word decoding and reading comprehension among students with low vision and account for variance in reading attainment. Gompel et al. (2002) stated that 70.9% of students in special schools and 45% of students in regular schools had additional disabilities; of these students, 40.6% listed learning difficulties, attention, or concentration problems as an additional problem.
The research literature implies that, due to visual field restrictions, a reader with low vision may experience a reduction in working memory that may affect reading comprehension. However, the presence of visual impairment among children with no other disabilities did not significantly affect comprehension rates (Gompel et al., 2002). Likewise, Gompel et al. (2004) substantiated that reading comprehension for children with low vision did not significantly differ from that of sighted peers.

**Reading with Low Vision Devices**

Literature exists on the use of magnification devices on reading outcomes for adults with low vision. Magnification is used for optimal viewing and reading of print materials by individuals with low vision. “Reading with a magnifier involves two separate tasks: processing the visual stimuli and moving the magnifier over the text” (Beckmann & Legge, 1996, p. 3723). Ahn and Legge explored the predictors of the magnifier-aided reading speed of adults with low vision. The score on the Minnesota Low Vision Reading Test (MNREAD) accounted for 79.7% variance in the magnifier-aided reading (Ahn & Legge, 1995). There was a statistically significant correlation between age and magnifier-aided reading rate and between age and the type of magnifier used. The type of magnifier also used significantly predicted magnifier-aided reading rate with standard correction only (SCO) having the fastest reading speed.

Even though it may be beneficial for readers with low vision, magnification can affect the reading process by decreasing the size of forward saccades, decreasing the field-of-view, changing eye movement patterns when fixating across a magnified page, and reducing oral reading rates (Dickinson & Fotinakis, 2000). Magnified text can reduce the number of characters in the viewing field or window size (Beckmann & Legge, 1996). When reading on a Closed Circuit Television
(CCTV) or video magnifier, a reader with low vision is moving the material or tray to the right and retracing a line back to the left. Beckmann and Legge (1996) described three qualitative differences for adults with low vision using a CCTV from users with typical vision: slower reading rates for the majority of users with low vision, longer forward-reading times, and increased window width size during page navigation. Following up to the Beckman and Legge study, Harland, Legge, and Luebker (1998) investigated manual methods and automatic page navigation methods (DRIFT and RSVP) among adults with low vision and typical vision. The manual methods were CCTV and MOUSE, a computer mouse for navigation, and automatic page methods were scrolling or DRIFT and rapid serial visual presentation or RSVP. Across the four navigation methods, adults with central field loss did not display significant differences in reading rates; however, adults with intact central fields read 40% faster on the automatic displays (Harland et al., 1998). Those factors for using a video magnifier or CCTV and automatic displays should be taken into consideration for training on the device for individuals with low vision.

Portable electronic video enhancement systems or p-EVES can be appealing to individuals with low vision over optical low vision aids because of the ability to view items at a typical reading distance, view with both eyes, vary the level of magnification, vary the contrast settings, and read for extended periods (Taylor et al., 2017). Taylor et al. (2017) employed a randomized crossover trial design to research the effectiveness of p-EVES and optical magnifiers for near vision activities, which contributes to the need for evidence-based practices in low vision rehabilitation. In adults with age-related macular degeneration, participants read the highest number of words correctly per minute with the iPad with a 9.7 inch screen than the Sony eReader or printed paper and had greater reading speeds on the iPad when print was greater than 24 point font (Gill et al., 2013). However, reading rates decreased all conditions as text size increased. In
the patient survey, adults with low vision reported paper as the easiest to use, but the iPad provided better clarity of the text.

The iPad can serve as a tool to access standard newsprint-sized text for older adults with low vision. Without the iPad, 22% of adults with low vision studied could read newsprint-sized text (Haji, Sambhav, Grover, & Chalam, 2015). Reading performance in adults with low vision was compared in three conditions: the Apple iPad, CCTV, and baseline of handheld magnifiers (Riley, Johnson, & Wittich, 2016). The number of words correctly read per minute on the International Reading Speed Test (iReST) passage was similar across all near reading aids. Despite the lack of statistical significance of reading rates across the conditions, 72% of participants preferred the iPad for reading due to size and portability, ability to vary viewing distance and position, and flexibility in changing text sizes (Riley et al., 2016). The second choice in reading devices and aids is the CCTV. From the literature, the outcomes suggest the use of portable electronic video enhancements systems may enhance near reading for adults with low vision and ability to read smaller text. Another consideration in determining low vision devices is personal preference and motivation of the user.

Recent literature regarding children reading with low vision devices and oral reading fluency is limited (Thomas et al., 2015). Lussenhop and Corn (2002) reviewed the current literature regarding reading performance in students with low vision. Eight quantitative studies conducted over 30 years were used. They found that after the introduction of low vision devices, students with low vision increased significantly in silent reading comprehension, but not significantly in oral reading (Lussenhop & Corn, 2002). For reading speed, no significant difference was found between oral reading rate with standard and large print. An extensive sample size study comprised of students with low vision enrolled in Project PAVE (Providing Access to the
Visual Environment) examined the use of low vision devices on oral reading rates, silent reading rates, and comprehension (Corn et al., 2002). Initial silent reading rates for each grade level were documented and were lower than sighted peers. Corn et al. noted the reading rates for students with low vision also trailed behind their peers after grade four, which is similar to findings by Lueck et al. (2003). Oral reading rates did not significantly increase after the introduction of low vision devices with standard print, but silent reading rates significantly increased (Corn et al., 2002). Silent reading comprehension significantly increased with the use of low vision devices throughout the study, especially in students in grades one through three.

Project Magnify, modeled after Project PAVE, used the Basic Reading Inventory (BRI) to assess ORF and comprehension at the beginning and end of the school year for students reading large print and students using magnifiers (Farmer & Morse, 2007). Students in the large print group maintained the same print size, instructional level, and increased oral reading rates. The magnifier group increased oral reading rates and demonstrated an improvement in comprehension with three students increasing instructional level by two levels (Farmer & Morse, 2007). All but two students in the magnifier group reduced their initial print size to 12 point standard print. More recently, Lusk (2012) examined the effects of four near magnification systems on oral reading fluency in students with low vision ranging from grade three to 11. The near reading magnifiers were handheld, stand-mounted, spectacle-mounted, and video. The oral reading rates and near reading preferences varied among the participants, but there was one participant whose data was relatively constant and indicated a superior condition (Lusk, 2012).

Huurneman et al. (2013) compared large print and use of a dome magnifier on reading a crowded near reading chart (using logMAR notation) on children with low vision ages four to eight years. With magnification, children four to six years old showed a significant improvement
in near vision of 5.3 log steps and children seven to eight years old improved near vision by 7 log steps. Visual acuity remained constant for the large print users.

The presentation of reading materials can be altered through video magnification or digital tools. Douglas, Kellami, Long, and Hodgetts (2001) compared the oral reading rates of children with low vision from the NARA presented on paper in large print in Arial 20 point font and Arial 20 point font on a 13 inch laptop computer screen. The mean across the conditions was six wpm slower on the computer than large print, yet no statistical significance existed between the reading conditions. When reading from a computer screen, Douglas et al. (2001) identified potential interacting factors to consider: posture, relative quality, and resolution of the text image, and individual reader characteristics. In the area of mathematics, students with visual impairments solved more problems correctly on an iPad application than on paper (Beal & Rosenblum, 2018). Students were more motivated to do math problems with the iPad app than on paper, and 78% of teachers reported student engagement with the iPad app. Seventy-eight percent of students preferred the iPad app for math problems.

A recent single-subject case research study examined oral and silent reading rates, fluency, and comprehension using two reading mediums for students with visual impairments (McLaughlin & Kamei-Hannan, 2018). The two reading formats were large print text on paper and the iPad 2. Three participants with visual impairments ranged in age from 12 to 17 years and were in the seventh, tenth, and eleventh grade with some technology experience. The participants received training from a certified Teacher of the Visually Impaired on how to use the iPad2 and Read2Go mobile application two to three times a week for four weeks. Then, the researchers implemented an alternating randomized treatment design of 24 oral and silent reading assessments on large print paper and 24 reading assessments on the iPad to assess the reading rate,
fluency, and comprehension from participant-selected books. McLaughlin & Kamei-Hannon (2018) found that overall reading speeds for all participants on the iPad were slightly higher than on large print paper and remained stable over time. No significant differences were noted for reading comprehension on either reading format. The miscue analysis indicated fluency errors were minimal between the two conditions and did not significantly impact comprehension rates.

**Evolution of Reading**

In modern society, the construct of literacy is changing and evolving due to the influence of technology. Literacy extends beyond the traditional print-based materials. There is a multitude of methods to access and interact with print, visual, and audio texts referred to multimodal texts (O’Brien & Scharber, 2008). The interaction and engagement with multimodal texts can be referred to as digital literacies. O’Brien and Scharber (2008) defined “digital literacies as socially situated practices supported by skills, strategies, and stances that enable the representation and understanding of ideas using a range of modalities enabled by digital tools” (p. 67). Common digital screen items used in educational settings are laptops, Chromebooks, and tablets. Digital literacies can complement and supplement the written text.

The theoretical framework for the current study is based on the integrative framework proposed by Mangen and van der Weel. Mangen and van der Weel (2016) advocated for an integrative theoretical framework for reading research that uses a transdisciplinary and a bottom-up approach to examine reading and effects of digitisation. The framework has two assumptions: “reading is an interaction with technology/device with specific interface affordances and cognition, hence, reading is embodied — it entails physical (in particular, manual/haptic) interaction with a device” (Mangen & van der Weel, 2016, p. 120). The framework has the following seven
dimensions: ergonomic, attentional/perceptual, cognitive, emotional, phenomenological, socio-cultural, and cultural-evolutionary (Mangen & van der Weel, 2016). Mangen and van der Weel further divide the reading process into three stages, which are preparation, the act of reading, and the effects or reading.

The research study examined and compared the interactions of students with low vision engaging with large print font on paper versus screen-based optical devices. The research study explored the preparation for the reading by addressing the text design of the passages, the interface characteristics of the devices, and the reading environment. The study also examined the ergonomic dimension or the physical engagement with the device and text by recording print size, size of text on the screen, and physical positioning. The act of reading was determined by measuring oral reading outcomes for all reading media, which addresses the cognitive and attentional/perceptual dimension.

The specific oral reading outcomes of interest are reading rate, fluency, and comprehension. In educational settings, the reading outcomes are measured over a designated period of time, which is typically a school calendar year, to indicate performance and progress after receiving instruction. The research questions aimed to examine the use of reading media and oral reading outcomes over time through repeated observations of performance.

**Research Questions**

1. Does a difference over time exist for the oral reading rates for children with low vision when using an iPad, video magnifier, or large print text? Hypothesis: Oral reading rates differ significantly among the reading media.
2. Does a difference over time exist for oral reading fluency for children with low vision when using an iPad, video magnifier, or large print text? Hypothesis: Oral reading fluency does not differ significantly among the reading media.

3. Does a difference over time exist for oral reading comprehension rates for children with low vision when using an iPad, video magnifier, or large print text? Hypothesis: Oral reading comprehension does not differ significantly among the reading media.

4. Exploratory: What type of fluency errors do children with low vision make when reading narrative passages aloud?
CHAPTER III

METHODS

The purpose of this section is to explain the methodology used to examine the use of an iPad, video magnifier, and large print text on oral reading outcomes for children with low vision. The independent variable for the proposed research study was students’ use of an Apple iPad, video magnifier, and large print text. Dependent variables were oral reading rates, oral reading fluency errors, and comprehension rates. The study sought to answer the following questions:

1. Does a difference over time exist for the oral reading rates for children with low vision when using an iPad, video magnifier, or large print text? Hypothesis: Oral reading rates differ significantly among the reading media.

2. Does a difference over time exist for oral reading fluency for children with low vision when using an iPad, video magnifier, or large print text? Hypothesis: Oral reading fluency does not differ significantly among the reading media.

3. Does a difference over time exist for oral reading comprehension rates for children with low vision when using an iPad, video magnifier, or large print text? Hypothesis: Oral reading comprehension does not differ significantly among the reading media.

4. Exploratory: What type of fluency errors do children with low vision make when reading narrative passages aloud?
Participants

Three subjects participated in the research study. Each participant chose a pseudonym for the study. Participants ranged in age from eight years to nine years 11 months. The participants were enrolled in two public schools in the United States. Alec and Lily attended the same elementary school. Luna attended an elementary school in a different school district. All participants had a special educational label of visual impairment as confirmed by their Individualized Education Plans (IEP) and had a best corrected visual acuity of 20/70 to 20/400 or a reduced visual field of 20 degrees or less as documented by ophthalmological reports and functional vision assessments. All participants participated in the general education setting for 80% or more of the school day. The participants all had previous assistive technology experience with an iPad and a video magnifier and were able to operate the devices independently. Lastly, Alec and Lily read at grade level, while Luna read at one grade level above her grade. None of the participants were receiving specific reading interventions at school or engaged in a Response to Intervention program (RTI). All participants received literacy instruction. See Table 1 for demographics of the participants.

Students without a visual impairment were excluded from this study due to the emphasis on reading outcomes for students with low vision. Additionally, students with complex needs or severe multiple disabilities were excluded. Severe multiple disabilities include a cognitive impairment two or more standard deviations from the mean and one or more of the following conditions: deaf and hard of hearing, visual impairment, physical impairment, and health impairment. For example, a participant with low vision and cognitive impairment or intellectual disability did not meet the inclusion criteria for the study. None of the participants in the study had a secondary disability category.
Table 1
Demographics

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Grade</th>
<th>Visual Impairment</th>
<th>Best Corrected Acuity</th>
<th>Critical Print Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alec</td>
<td>9:04 to 9:05</td>
<td>4</td>
<td>Congenital Cataracts, Nystagmus</td>
<td>20/200 OU</td>
<td>24 point</td>
</tr>
<tr>
<td>Lily</td>
<td>8:07 to 8:08</td>
<td>3</td>
<td>Oculocutaneous Albinism, Nystagmus</td>
<td>20/150 OU</td>
<td>38 point</td>
</tr>
<tr>
<td>Luna</td>
<td>9:10 to 9:10</td>
<td>4</td>
<td>Congenital Cataracts, Glaucoma, Traumatic Optic Neuropathy</td>
<td>20/20 OS, 20/5000 OD</td>
<td>14 point</td>
</tr>
</tbody>
</table>

*Note: OD = right eye, OS = left eye, OU= both eyes*

Alec

Alec was a nine-year-old male of Chinese ethnicity. He was in the fourth grade at a public elementary school. Alec was born in China and moved to the United States when he was adopted at age five. Alec had been receiving services under the visual impairment category for the past three years. He had a visual diagnosis of congenital cataracts with a best correction visual acuity of 20/200. No other medical conditions or prescription medications were noted or disclosed. The school has not conducted intelligence testing (IQ) on Alec. Alec was in good academic standing at the beginning of the study and was considered to be at an average to higher range for reading compared to his peers. He received daily reading group instruction for 60 minutes and reading and writing instruction of 45 minutes.
Alec wore glasses full-time at the time of the study. Approximately one week before the start of data collection, he received new prescription lenses with a bifocal and stated he was adjusting to the change. For the last six reading passages and the NARA posttest, Alec did not wear glasses because they were broken.

He received services from a Teacher of the Visually Impaired four days a week for 45 minutes. Alec was a dual media learner with print as his primary reading medium and braille as a secondary medium. As for assistive technology, he used a SmartView desktop video magnifier at school for regular print materials and occasionally a Connect 12 video magnifier at home. Alec participated in the school academic team and enjoyed playing soccer.

Lily

Lily was an eight-year-old female student of Caucasian ethnicity. She was in the third grade at a public elementary school. Lily was born in the same state in which she resides. She had been receiving services under the visual impairment category for the past three years. Lily had a visual diagnosis of oculocutaneous albinism and nystagmus with a best corrected distance visual acuity of 20/150. Prescription lenses were prescribed for full-time use. Lily wore prescription glasses for all sessions during the study. No other medical conditions or prescription medications were noted or disclosed. The school has not conducted intelligence testing (IQ) on Lily. At the beginning of the study, Lily was in good academic standing and was considered to be at an average to lower reading level compared to her peers. She received daily reading instruction for 60 minutes, reading groups for 75 minutes, and writing instruction for 35 minutes. Lily received services from a Teacher of the Visually Impaired twice a week for 30 minutes. Her
primary learning media is print. As for optical devices and assistive technology, she had a dome magnifier, slant board, and Visiobook at school. She enjoyed soccer and physical education.

**Luna**

Luna was a nine-year-old female student of Caucasian ethnicity. She was in the fourth grade at a public elementary school. She was born in the same state in which she resides. Luna had a visual diagnosis of congenital cataracts, glaucoma, and traumatic optic neuropathy. The best corrected near acuity was reported in the Functional Vision Assessment as 20/70 in both eyes and distance acuity as reported in an ophthalmologist report as 20/20 in the left eye and 20/5000 in the right eye. Prescription lenses with a bifocal were prescribed for full-time use. Luna wore prescription glasses for all sessions during the study. No other medical conditions or prescription medications were noted or disclosed. The school has not conducted intelligence testing (IQ) on Luna. At the beginning of the study, Luna was in good academic standing and was considered to be at a high reading level compared to her peers. She received daily reading and writing instruction for 110 minutes and language arts instruction for 55 minutes.

She had been receiving services under the visual impairment category for one year. Luna received services from a TVI once a week for 30 minutes. At school, she used a dome magnifier, large print books, and an iPad. She enjoyed reading books and participated in dance.

**Procedures**

The research design was a single-case, repeated acquisition design. Single Case Research (SCR) is a “rigorous, scientific methodology” used to “document causal or functional relationships between independent and dependent variables” (Horner et al., 2005, p. 168). It is frequently
used in special education, particularly to examine low-incidence populations due to the heterogeneous nature of the disabilities. Horner et al. (2005) stated SCR is well-suited for the field of special education, because it focuses on the individual student, analyzes all participants and examines intervention and the outcomes, and allows for analysis in typical educational settings. Since single-case design will enable participants to serve as their own control, this design is ideal for children with low vision.

The repeated acquisition design (RA) was intentionally selected for this research study. The design is “used when the behaviors of interest will be quickly acquired by the participant and when two interventions are being compared” (Gast & Ledford, 2014, pp. 357-8). Repeated Acquisition is an adapted alternating treatment design that focuses on the measurement of non-reversible behaviors (CEC-DR, 2018). Once a child has learned to use the reading media, the child cannot unlearn or reverse the skill. Repeated Acquisition can be used when comparing two or more interventions (Gast & Ledford, 2014). For this study, the interventions being compared are the use of an iPad, video magnifier, and large print text. Furthermore, the RA design involves repeated measures or comparisons over multiple sessions under each condition, which can be analyzed for any intra-participant changes over time. “Continuous assessment over time provides the observations required to compare performance under different conditions” (Kazdin, 2019).

To investigate reading outcomes, the study sought to examine the results over time but restricted the time of year to the fall to minimize potential effects of instruction. Oral reading rate norms in the fall are similar to the previous spring norms. To compare performance over time, the study measured time in weeks to potentially mitigate practice effects and minimize external factors such as illness or special school events. To demonstrate a relationship between the
variables, a functional relation requires a minimum of five data points. Thus, the study length was designated for six weeks.

A research study proposal was approved by the Human Subjects Institutional Review Board (HSIRB) at Western Michigan University (Appendix A). A recruitment email and flyer (Appendix B) was distributed to the listserv for Teachers of the Visually Impaired across the Commonwealth of Kentucky. Teachers of the Visually Impaired were chosen due to their direct connection with students with low vision. Site approval (Appendix C) and informed consent (Appendix D) were obtained. Then, eligibility of the participants was confirmed by reviewing the IEPs and ophthalmological reports provided by the Teacher of the Visually Impaired. Each interested participant and the Teacher of the Visually Impaired met with the researcher in order for the researcher to explain the study participation, answer any questions, and obtain student assent (Appendix E). Data collection began after the appropriate HSIRB forms were signed (Appendix F).

The MNREAD application was used to determine the critical print size, or smallest font size at the maximum reading speed, for the reading passages for each participant preceding the beginning of data collection. More information on the MNREAD is in the measures section. The iPad Pro was used to administer the print size assessment in a small windowless room with overhead fluorescent lighting. Each participant wore prescription glasses for the assessment.

After determination of critical print size, each participant’s independent reading level was determined. The font size in forms and passages given to each participant were based upon individualized results from the MNREAD assessment. Reading level is crucial for conducting the pretest and posttest measures and oral reading assessments. The independent reading level is when the student can independently and fluently read text with few errors and with excellent
comprehension (Johns, 2008). The types of material at this level should be “all schoolwork to be completed alone, pleasure reading, and informational reading” (Johns, 2008, p. 10). The Quality Reading Inventory (QRI) was used to determine the level. The QRI is an informal assessment instrument measuring oral reading accuracy, reading rate, and comprehension using word lists and passages (Leslie & Caldwell, 2017). The narrative passages were used for the leveling.

To address internal threats to validity, the Neale Analysis of Reading Ability Revised (NARA), an oral reading assessment, was given as a pretest to all participants to establish a baseline in oral reading rate, fluency, and comprehension. Testing occurred in a separate windowless room with overhead fluorescent lighting. Form 1 was used for the pretest and Form 2 for the posttest. On the NARA II, students could use an optical device or video magnifier to read the test passages. Data on the participants’ reading speed, fluency, comprehension, and types of fluency errors were recorded.

Once baseline measures were obtained, eighteen different oral reading assessment passages based on the subject’s independent reading level were administered over six weeks from October to the end of November. The passages were from FastBridge Learning CBMreading COMP™. Three assessment passages were given to each participant on one school day with a minimum of one hour between each reading. Classroom teachers gave preferred times to remove the participants from class to minimize the loss of teacher-led instruction. The session time and day were documented for every session. Sessions occurred in a small windowless room with overhead fluorescent lighting. The iPad, video magnifier and large print text were systematically alternated for each reading passage for each participant. Reading rate, fluency errors, and answers to comprehension questions were recorded on the paper copy of the passages and in a data spreadsheet. After eighteen sessions are completed, students were given a posttest
using NARA Form 2. A second evaluator and student investigator reviewed the audio and video recordings of the oral reading assessments to ensure a minimum of 80% on the interrater observer agreement.

**Measures**

The Apple iPad used for the study was an Apple iPad Pro (see Figure 1). The iPad Pro had a width of 6.8 in. and a length of 9.8 in. The diagonal retina display was 10.5 in. and had a LED-backlit multi-touch display. The screen resolution was 2224 X 1668 at 264 pixels per inch (ppi) and had a 120Hz refresh rate. The camera was a 12-megapixel and had optical image stabilization. A newer feature of the iPad Pro was ProMotion technology, which automatically adjusts and improves the display quality (Apple Inc., 2018). Also, the True Tone feature could change the white balance of the display to reflect the current lighting conditions. The last items of note are the accessibility features, which are standard among all iPad models. The accessibility features for vision are VoiceOver (screen reader), Zoom (screen magnifier), magnifier, display accommodations, and font adjustments (Apple Inc., 2018).

![Figure 1](https://www.apple.com)

*Figure 1. Photograph of an Apple iPad Pro with 10.5 inch screen. Photograph from Apple at apple.com*
For the video magnifier, a desktop model (Connect 12 electronic magnifier by HumanWare) was used. The Connect 12 (see Figure 2) is a thin, portable device without an X-Y table. This particular model was selected because the screen size, display, and resolution were similar to the Apple iPad Pro. The screen dimensions were 11.9 in. in width by 7.3 in. in length. The diagonal LED screen display was 11.6 in. with a screen resolution of 1920 X 1080 (full HD). The camera was 13 megapixels Ultra High Definition (UHD). The device functions as an electronic or video magnifier and had standard features associated with a tablet device. The Connect 12 had enhanced contrast options such as full color, positive, negative, and Diamond Edge Text. The Diamond Edge Text allows the user to magnify the print without any pixilation or distortion of the print clarity (HumanWare, 2018). It had a bold and regular system font with a medium, large, very large, and extra-large font sizes. There were 20 different color schemes for the Connect 12.

![Figure 2. Photograph of a Connect 12 electronic magnifier. Photograph from HumanWare at humanware.com0023](image)

The MNREAD application was used to determine the critical print size for the reading passages for each participant. The MNREAD (see Appendix G) is a continuous-text reading-
acuity test for individuals with normal and low vision ranging in age from eight to 80 years (Calabrèse et al., 2016). The MNRead was developed to assess one’s reading acuity, maximum reading speed, and critical print size. Reading acuity is the smallest size print one can read, maximum reading speed is when a constant speed is reached across a range of print sizes, and critical print size is smallest print size read with maximum speed (Virgili et al., 2004).

The test consisted of sentences with 60 characters comprised of high-frequency words at a second to third grade reading level that was presented on three lines of equal length in nineteen print sizes (Calabrèse et al., 2018). Each participant read the sentences on the iPad with the MNREAD test app, and the assessor recorded the number of errors and the reading time. The brightness level was set at 75% as recommended in the MNREAD manual. The MNREAD app estimated maximum reading speed and critical print size, which were plotted on a graph.

Before the intervention, the MNREAD application was used to determine the critical print size for the large print passages. The assessment environment was similar across all participants. Each participant was assessed in a separate room within the school building with overhead fluorescent lighting. All three participants were wearing corrective lenses for the pre-intervention assessments.

Alec’s maximum reading speed was 105 words per minute (wpm) with 24 point font at a reading distance of 24 cm. There was a +.22 logMAR correction for the reduced viewing distance that increased his critical print size to 38 point font. For the intervention assessment, Alec preferred to use 24 point font print versus the 38 point font print. Lily’s maximum reading speed was 96 wpm with 38 point font at a distance of 40 cm. Luna’s maximum reading speed was 91 wpm with 12 point font at a distance of 25 cm. Due to the reduced viewing distance, a logMAR correction of +.22 was made to adjust the critical print size to 14 point font.
Updated 2017 oral reading fluency norms have been compiled for students in grades one through six divided into percentiles and fall, winter, and spring levels (Hasbrouck & Tindal, 2017). The norms are derived from commercially-available oral fluency assessments and are based upon words correct per minute. The spring norms for a grade level are most similar to the fall norms for the next grade. The primary focus is oral reading fluency norms in the third and fourth grades (see Table 2).

Table 2
Compiled ORF Norms 2017

<table>
<thead>
<tr>
<th>Grade</th>
<th>%ile</th>
<th>Fall WCPM</th>
<th>Winter WCPM</th>
<th>Spring WCPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>90</td>
<td>134</td>
<td>161</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>104</td>
<td>137</td>
<td>139</td>
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<td></td>
<td>50</td>
<td>83</td>
<td>97</td>
<td>112</td>
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<td></td>
<td>25</td>
<td>59</td>
<td>79</td>
<td>91</td>
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<tr>
<td></td>
<td>10</td>
<td>40</td>
<td>62</td>
<td>63</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>153</td>
<td>168</td>
<td>184</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>125</td>
<td>143</td>
<td>160</td>
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<td></td>
<td>50</td>
<td>94</td>
<td>120</td>
<td>133</td>
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<td>25</td>
<td>75</td>
<td>95</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>60</td>
<td>71</td>
<td>83</td>
</tr>
</tbody>
</table>


The independent reading level for each participant was determined by using narrative passages from the Quality Reading Inventory (QRI), sixth edition (Leslie & Caldwell, 2017). When presented with a vertical list of 20 words, one’s independent level was considered to be the correct identification of 18 to 20 words. The oral reading word list and narrative reading
passages were presented in the critical print size for each participant. Alec was at the independent level on the fourth grade word list by correctly identifying 19 of 20 words. Given reading passages at three grade levels, Alec had an independent level in fluency and comprehension on the fourth grade reading passage. Lily scored at the independent level on the third grade list with 19 of 20 words read correctly and was at an independent level on the third grade passage. Luna scored at the independent level on the fifth grade word list by correctly identifying 19 of 20 words and read at an independent reading level on the fifth grade passage.

Repeated acquisition does not require the use of a pretest and posttest measure, which is a design limitation. Potential internal threats to validity are history, maturation, and instrumentation. To address internal threats to validity, the Neale Analysis of Reading Ability II (NARA) was used as a pretest and posttest assessment measure. The use of the NARA was to provide more comprehensive data on the participants’ national percentile rank and reading age compared to peers with typical vision and compared to peers with low vision and to assess the primary study variables. The NARA is a norm-referenced reading test for children ages 6 to 12 years 11 months (Neale, 1997). It assesses oral reading accuracy, comprehension, and rate and compares them to national norms for children at the same age level. The NARA has two parallel graded forms (1 and 2—see Form 1 in Appendix I) with narrative passages, which are standardized, and diagnostic tutor forms, which are not standardized. Participants could use low vision aids such as a video magnifier or optical magnifiers to read the standard assessment forms. The reading passages were only available in a print booklet format and were not available on the iPad.

The NARA has six levels of reading passages in each of Form 1 and Form 2. The number of words per passage varies upon the level of the passage, which increases from level 1 (Appendix J) to level 6. Level 1 begins at 26 words then level 6 progresses to 141 words. The
NARA reading passages were in a preset font type and font size. For the level 1 passage, the text size was 0.5 cm in a sans serif font with 1.6 cm line spacing, and the level 2 passage had a text size 0.5 cm in a sans serif font with 0.9 cm lane spacing. A serif font was used for level three, four, five, and six passages. For level three (Appendix K) and four passages, the font was constant at 0.5 cm in height, and line spacing was set to 0.6 cm. Font size and line spacing height were set to 0.4 cm for the level five passage. Lastly, the level six passage font height decreased to 0.3 cm, while the line spacing in Form 1 was used for the pretest, and Form 2 was used for the posttest.

The reading rate was calculated by dividing the total number of words by the total time and multiplying by 60. Next, the types of fluency errors were recorded and categorized. The fluency error categories were the following: mispronunciations, substitutions (changing a word with another), refusals (did not read the word aloud), additions (added a word or words), omissions (skipped a word or words), and reversals (changed the order of the words). Each error was counted then given as a percentage of the total count of words. The total number was calculated by dividing the fluency error count by total count and multiplying by 100. Comprehension was assessed by verbally asking the participant eight open-ended questions about the passage. The comprehension questions used basic information gathering techniques using who, what, where, when, and how. An example of a comprehension question is “How did Leo know where the diver was?” (Neale, 1997). Furthermore, the NARA has a qualitative assessment component allowing the evaluator to notate general details, attitude towards school and reading, and reading behaviors such as articulation, using a finger as a pointer, head movements, and distance to materials.

The NARA individual record was used by each evaluator to record the rate, fluency, and comprehension for each form to complete the assessment. Two evaluators assessed the oral
reading outcomes by watching audio and video recordings. The second evaluator received training by the student researcher on how to mark fluency errors and record comprehension rates.

Upon completion of the assessment, the raw score summary was converted to standardized scores using the NARA conversion tables. The standardized score summary reported the child’s reading age, standardized score in accuracy, comprehension, and rate, national percentile rank in accuracy, comprehension, and rate, and stanine. The national percentile rank was measured by “the percentage of pupils in the sample of the same age who gained a score at the same level or below that of the child’s score” (Neale, 1997, p. 28). The use of stanines refers to the “broad units equal to approximately one-half of a standard deviation in with and the mean being the mid-point of the fifth (or middle stanine)” (Neale, 1997, p. 28).

The Visual Impairment Centre for Teaching and Research at the University of Birmingham developed a supplementary manual to aid and guide the NARA assessment of children with low vision (Hill, Long, Douglas, Tobin, & Grimley, 2005). The NARA for readers with low vision compared oral reading outcomes of the child with low vision to peers with low vision and the child with low vision to normally sighted peers. The manual served as a guide to reporting oral reading outcomes for the participants with low vision. A corresponding visual impairment reading age along with the reading age for normally sighted peers and 95% confidence band was given for the raw scores in accuracy, comprehension, and rate.

Following the NARA, a different independent reading level passage for each participant was given at each data collection session. FastBridge Learning granted permission and access (Appendix L) to the print versions of CBMreading COMP\textsuperscript{TM}. Formative Assessment System for Teachers (FAST\textsuperscript{TM}) was developed by Dr. Christ and Dr. Borbora in 2010 as an efficient and effective cloud-based system that educators could use for managing data, conducting
assessments, and determining specific instructional strategies and interventions for students (FastBridge Learning, 2019). FastBridge Learning was established in 2015 as a partnership between the University of Minnesota, Dr. Theodore J. Christ and Colleagues (TJCC) and the FAST team (FastBridge Learning, 2019). FastBridge Learning products can be used for universal screenings in reading, math, and social-emotional behaviors in addition to curriculum-based measurements in reading and math skills. The product of focus is the CBMreading COMP™, which is “a supplemental assessment to CBMreading for grades 1 to 8 universal screening and progress monitoring” (FastBridge Learning, 2019, Reading section, para. 3).

Passages from CBMreading COMP™ levels three, four, and five were utilized. The large print text passages were printed on standard white printer paper in the participant’s critical print size and were unbound. The passages were printed in a sans serif font (see sample in Appendix M). An example of the text is 14 point font Century Gothic. This font was chosen based upon the type face used in the FastBridge Learning CBMreading COMP™ passages. On the iPad, the passages were converted to a pdf file and uploaded to iBooks.

When a passage was read by a participant, reading rate or words per minute was measured using a stopwatch and recorded on the scoring sheet. Fluency errors were noted as substitutions, mispronunciations, insertions, omissions, and reversals. Repeated errors were only counted once such as Tim for Tom. Immediately following a passage, the participant was asked 10 comprehension questions specific to the passage. The two categories of comprehension questions were explicit and inferential knowledge. The responses were recorded as a percent correct out of 10.
Data Analysis

Descriptive statistics were conducted. A descriptive narrative of each participant was included with basic demographics such as age, grade, visual impairment diagnosis, visual acuity, reading level, and time spent in general education. Reading behaviors and viewing settings on the iPad and electronic magnifier were included.

Next, the oral reading rate, fluency, and comprehension scores for each condition were input into a spreadsheet and graphed for each participant. The median score for each reading medium was calculated. In addition to the oral reading outcomes, the amount and type of fluency errors were recorded and described for each participant. The outcomes are reported in a table format. As reported in a study of oral reading outcomes assessed by the NARA, children with low vision tended to make more substitutions than mispronunciations than typically sighted peers (Douglas, Grimley, McLinden, & Watson, 2004). This study would explore the type of errors made by children with low vision.

Visual analysis was completed for all participants to examine trends within condition data and patterns across conditions to determine whether changes occurred over time for oral reading outcomes across reading media. Then, a visual analysis of the graphs was completed to examine the use of the iPad, video magnifier, and large print text across participants. The median level was used as recommended for single-case research studies by Gast and Ledford (2014). The visual analysis of the graphs assessed level stability, which is the amount of the variability or range of data point values in a condition. The slope of the data points was analyzed to identify accelerating, decelerating, or zero-celerating trend lines. Data points that moved in a decelerating trend line would indicate fewer words per minute and zero-celerating trend line would indicate no change or a plateau. Trend stability was determined by examining the number of data points
that were within the stability envelope of 25% of the median value. After examining the factors, the analysis yielded data to determine whether a functional relation existed between the use of the iPad, video magnifier, and large print on oral reading rate, fluency, and comprehension.

Summary

The study sought to analyze the relationship between the use of an iPad, video magnifier, and large print text on oral reading rate, fluency, and comprehension among children with low vision. A single-case research design was chosen to examine and analyze the research questions. Single-case research is frequently used with low incidence populations. The study used a repeated acquisition design to examine the relationship of using an iPad, video magnifier, and large print text on oral reading rates, fluency, and comprehension. First, critical print sizes and independent reading levels were determined for each participant. Then, as a pretest and posttest measure, the NARA was administered to determine the oral reading rate, fluency, and comprehension and report reading age. Lastly, participants read three different CBMreading COMP™ passages in large print, on the iPad, and the video magnifier once a week for six weeks from October to the end of November. After data collection was completed, the reading outcomes were graphed, visually analyzed for each participant, and visually analyzed across participants.
CHAPTER IV

RESULTS

The purpose of this section was to report the results of the study by addressing the oral reading outcomes of the participants, the three primary research questions, and one secondary research question. First, graphs of the participants’ oral reading outcomes were examined to determine the individual oral reading rate, fluency errors, and reading comprehension of each participant for each reading medium. Second, graphs were visually analyzed to compare the results across participants. Lastly, the amount and type of oral reading fluency errors was determined and compared to previous research literature.

NARA Pretest and Posttest Participant Oral Reading Outcomes

A copy of the NARA Form 1 can be found in Appendix I. Form 1 was used for the pretest, and Form 2 was used for the posttest for all participants. For the NARA administration, participants were tested separately in a small windowless room with overhead fluorescent lighting. Lily and Luna wore corrective lenses. However, Alec wore corrective lenses for the NARA pretest but not for the posttest due to breaking them.

Interrater observer agreement (IOA) for Alec was collected for 50% of the pretest session and was collected for 100% of the posttest session. The IOA for errors was 96% for the pretest and 97% for the posttest. For comprehension, IOA was 100% on the posttest. Pretest comprehension IOA was not computed due to complications with the video recordings. Interrater observer agreement for Lily was collected for 100% of the pretest and posttest sessions. The IOA
was 100% on errors and comprehension for both sessions. For Luna, IOA was collected for 100% of the posttest session and the IOA was 100% for both errors and comprehension. Pretest IOA was unavailable due to issues with the video recordings.

Alec

Alec used the Connect 12 to magnify the NARA reading passages for pretest and posttest. The print size was magnified to one centimeter. Alec read black text on a white background. His viewing distance to the MATT Connect screen was 14 to 16 inches. On the day of the pretest, Alec’s age was nine years and four months and was nine years and five months on the day of the posttest. His accuracy pretest reading age was 11 years and 10 months with a national percentile rank of 78% and a stanine of seven. When compared to peers with typical sight, Alec’s reading age was one year and six months ahead of his chronological age. When compared to peers with low vision, his reading age was 15 years and eight months, which is six years and four months ahead of his chronological age. The posttest outcomes in accuracy were 10 years and one month for reading age, a percentile rank of 63%, and a stanine of six. Differences were noted between the pretest and posttest. The accuracy reading age decreased by one year and nine months, by 15% in the national percentile rank, and by one stanine. However, when compared to peers with typical sight, Alec had an accuracy reading age above his chronological age of eight months.

The pretest reading comprehension results were 11 years four months for reading age, 74% national percentile rank, and a stanine of six. The posttest results were 10 years and four months for reading age, 66% national percentile rank, and sixth stanine. The reading age for comprehension decreased by one year while the national percentile rank decreased by 8%. The stanine remained the same. The overall comprehension reading age compared to peers with
typical sight was higher than his chronological age by 11 months, and reading age compared to peers with low vision was higher than chronological age by four years and two months.

Alec’s pretest reading rate age was eight years and one month with a 30% national percentile rank and a stanine of four. When compared to peers with typical sight, his pretest reading rate age was below his actual age of nine years and four months. His visual impairment reading age was five months below the average of nine years. The posttest yielded an increase in age to 10 years and two months, a national percentile rank of 60%, and a stanine of five. Alec’s reading rate age increased from eight years and one month to 10 years and two months. The national percentile rank increased from 30% to 60% and increased one stanine. On the posttest for reading rate, Alec had a reading age higher than his chronological age by seven months when compared to peers with typical sight. His reading age compared to peers with visual impairments was 12 years, which was an increase of three years from the pretest. See Figure 3.

**NARA II National Percentile Rank for Alec**

![Bar chart](chart.png)

*Figure 3. Alec’s NARA national percentile rank in oral reading outcomes.*
The NARA fluency error analysis revealed a total of 22 errors on the pretest with 13 mispronunciations and nine substitutions. There were a total of 16 errors on the posttest. The errors consisted of nine mispronunciations, six substitutions, and one addition. The number of mispronunciations decreased by four words and the number of substitutions decreased by three words.

Lily

Lily used the Connect 12 to magnify the NARA reading passages for the pretest and posttest. Her viewing distance from the Connect 12 screen was 16 inches. Lily read black text on a white background. For levels one and two, she magnified the text to a half centimeter but increased the magnification to one centimeter for levels 3 and 4. It is important to note that Lily was not feeling well for the posttest. She had been absent the day before and requested to discontinue reading after the level 3 passage even though she did not reach the ceiling.

Lily’s chronological age at the pretest date was eight years and seven months, and eight years and eight months at the posttest date. When compared to peers with typical sight, the pretest for oral reading accuracy yielded a reading age of eight years and five months, a national percentile rank of 45%, and a stanine of five. Lily’s visual impairment reading age was 10 years and four months, which is one year and nine months ahead of her chronological age. The posttest results in accuracy showed a decrease in reading age of eight months, a decrease in national percentile rank of 13%, and a decrease of one stanine. Lily’s visual impairment reading age decreased from 10 years and four months to eight years and seven months, a one year and 10 months difference.
The comparison between pretest and posttest reading comprehension demonstrated a decrease in Lily’s reading age compared to peers with typical sight by nine months and a decrease in reading age compared to peers with low vision by one year and seven months. In contrast, the pretest and posttest comparison in reading rate demonstrated an increase in reading age by two years 10 months, an increase of national percentile rank of 42%, and an increase of two stanines. Compared to peers with typical sight, her reading rate age was nine months ahead of her chronological age. Then, compared with peers with low vision, Lily’s reading rate age increased from six years and three months to 10 years and seven months, an increase of four years and four months. See Figure 4.

\[
\text{\textit{NARA II National Percentile Rank for Lily}}
\]

![Graph showing NARA II National Percentile Rank for Lily](image)

\textit{Figure 4.} Lily’s NARA national percentile rank in oral reading outcomes.

The \textit{NARA} fluency error analysis revealed 18 errors on the pretest with seven mispronunciations, seven substitutions, three refusals, and one addition. The posttest analysis totaled 12 errors. The posttest errors constituted five mispronunciations, two substitutions, four refusals,
and one addition. The number of substitutions decreased by five words while the number of refusals was constant.

**Luna**

For the pretest and posttest, Luna read the *NARA* print booklet for levels one, two, and three but used a dome magnifier for levels four, five, and six. Her viewing distance for the beginning passages was 16 inches but decreased to approximately nine inches when using the dome magnifier. Luna’s age at the pretest date was nine years and 10 months. At the posttest date, Luna’s age was nine years and 11 months. When compared to peers with typical sight, the pretest results for reading accuracy showed a reading age of 12 years and seven months, a national percentile rank of 80%, and a stanine of seven. The posttest results demonstrated a decrease in Luna’s reading age of three years and six months, a decrease in percentile rank of 43%, and a decrease of three stanines. Luna’s accuracy reading age was 12 years and seven months which is two years and nine months ahead of her chronological age.

When compared to peers with visual impairments, Luna’s pretest visual impairment reading age in accuracy was 16 years and six months, which was six years and six months ahead of her chronological age. The posttest visual impairment accuracy reading age decreased to 11 years and four months but was still ahead of Luna’s chronological age by one year and four months. When compared to peers with typical sight, the pretest and posttest results in reading comprehension yielded overall decreases in reading age of three years and six months, a decrease in percentile rank of 42%, and a decrease of two stanines. Luna’s visual impairment reading age decreased from 16 years and 10 months to 12 years but was two years and one month ahead of her chronological age. However, in reading rate age compared to peers with typical sight, there
was an increase of one year three months, an increase of 17% in national percentile rank, and an increase of one stanine. When compared to peers with visual impairments, Luna’s reading rate age increased from 14 years to 16 years and nine months, which was six years and 11 months ahead of her chronological age. See Figure 5.

On the pretest NARA fluency analysis, Luna had a total of 17 errors with 13 mispronunciations, one substitution, and three omissions. On the posttest analysis, she had a total of 12 errors. The posttest errors constituted one mispronunciation, four substitutions, four additions, and three omissions. The number of mispronunciations decreased by 12, while the number of additions increased by four words.

*Figure 5. Luna’s NARA national percentile rank in oral reading outcomes.*
Overall Comparison

Each participant demonstrated a decrease in reading age, national percentile rank, and stanine in reading accuracy and comprehension compared to peers with typical sight on the posttest. Luna had the most significant change in accuracy and comprehension reading ages and in national percentile rank from the pretest to the posttest. On the pretest, Alec and Luna had accuracy and comprehension reading ages above their chronological ages, but Lily had accuracy and comprehension reading ages slightly below her chronological age. Alec and Lily both had reading rate ages below their chronological age; Luna had a reading rate above her chronological age. In terms of reading rate, all three participants demonstrated an increase from the pretest to the posttest of at least one year in national percentile rank and stanine when compared to peers with typical sight. Alec and Lily had reading rate ages below their chronological ages on the pretest and significantly increased their reading rate age above their chronological ages on the posttest, while Luna increased her reading rate age an additional year and three months ahead of her chronological age.

In comparison to peers with visual impairments on the pretest, all participants had a visual impairment reading age above their chronological age in accuracy and comprehension but not in reading rate except for Luna. Alec and Lily had a visual impairment reading age in reading rate below their chronological age. However, on the posttest, all participants had a visual impairment reading rate age above their chronological age. See Table 3.
Table 3
NARA Pretest and Posttest Standardized Score Summary

<table>
<thead>
<tr>
<th>Area</th>
<th>Rdg Age</th>
<th>68% Confidence Band</th>
<th>VI Reading Age</th>
<th>95% Confidence Interval</th>
<th>National Percentile Rank</th>
<th>Stanine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>11:10</td>
<td>11:03 to 12:11</td>
<td>15:08</td>
<td>13:05 to 18:9</td>
<td>78%</td>
<td>7</td>
</tr>
<tr>
<td>Comprehension</td>
<td>11:04</td>
<td>10:007 to 12:06</td>
<td>14:07</td>
<td>12:07 to 17:04</td>
<td>74%</td>
<td>6</td>
</tr>
<tr>
<td>Rate</td>
<td>8:01</td>
<td>7:00 to 9:04</td>
<td>9:00</td>
<td>7:05 to 11:04</td>
<td>30%</td>
<td>4</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>10:01</td>
<td>9:00 to 11:00</td>
<td>13:04</td>
<td>11:05 to 15:11</td>
<td>63%</td>
<td>6</td>
</tr>
<tr>
<td>Comprehension</td>
<td>10:04</td>
<td>9:04 to 11:03</td>
<td>13:07</td>
<td>11:09 to 16:04</td>
<td>66%</td>
<td>6</td>
</tr>
<tr>
<td>Rate</td>
<td>10:02</td>
<td>8:07 to 11:10</td>
<td>12:00</td>
<td>10:02 to 15:04</td>
<td>60%</td>
<td>5</td>
</tr>
<tr>
<td>Lily</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>8:05</td>
<td>7:07 to 9:02</td>
<td>10:04</td>
<td>8:10 to 12:04</td>
<td>45%</td>
<td>4</td>
</tr>
<tr>
<td>Comprehension</td>
<td>8:01</td>
<td>7:07 to 8:09</td>
<td>9:03</td>
<td>7:11 to 11:0</td>
<td>34%</td>
<td>4</td>
</tr>
<tr>
<td>Rate</td>
<td>6:07</td>
<td>5:09 to 7:01</td>
<td>6:03</td>
<td>5:02 to 7:11</td>
<td>18%</td>
<td>3</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>7:09</td>
<td>7:01 to 8:05</td>
<td>8:07</td>
<td>7:05 to 10:04</td>
<td>32%</td>
<td>4</td>
</tr>
<tr>
<td>Comprehension</td>
<td>7:04</td>
<td>6:11 to 7:11</td>
<td>7:08</td>
<td>6:07 to 9:02</td>
<td>22%</td>
<td>3</td>
</tr>
<tr>
<td>Rate</td>
<td>9:05</td>
<td>8:01 to 11:03</td>
<td>10:07</td>
<td>9:00 to 13:03</td>
<td>60%</td>
<td>5</td>
</tr>
<tr>
<td>Luna</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>12:07</td>
<td>10:09 to 13:05</td>
<td>16:06</td>
<td>14:02 to 19:09</td>
<td>80%</td>
<td>7</td>
</tr>
<tr>
<td>Comprehension</td>
<td>12:10+</td>
<td>11:03+</td>
<td>16:10</td>
<td>14:06 to 20:00</td>
<td>84%</td>
<td>7</td>
</tr>
<tr>
<td>Rate</td>
<td>11:07</td>
<td>9:07 to 13:02</td>
<td>14:00</td>
<td>11:07 to 17:08</td>
<td>70%</td>
<td>6</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>9:01</td>
<td>8:02 to 9:10</td>
<td>11:04</td>
<td>9:08 to 13:09</td>
<td>37%</td>
<td>4</td>
</tr>
<tr>
<td>Comprehension</td>
<td>9:04</td>
<td>8:08 to 10:00</td>
<td>12:00</td>
<td>10:04 to 14:05</td>
<td>42%</td>
<td>5</td>
</tr>
<tr>
<td>Rate</td>
<td>12:10+</td>
<td>10:09 to +</td>
<td>16:09</td>
<td>14:03 to 22:07</td>
<td>87%</td>
<td>7</td>
</tr>
</tbody>
</table>

Reading Rate Data by Reading Medium for Participants

Each participant was assessed in a small, windowless room with overhead fluorescent lighting. Three data sessions occurred once a week for six weeks from October to the end of November. Eighteen different CBMreading COMP™ passages were administered. The reading medium and time of day assessed was rotated for each participant. The schedule for data collection can be found in Appendix N. The median scores for reading rate, fluency errors, and
reading comprehension for each reading medium were calculated. Interrater observer agreement (IOA) was completed by watching the audio and video recordings for 100% of the sessions for all three participants after the completion of data collection. The IOA was 98% on errors and 100% on comprehension for Alec, 100% on errors and 100% on comprehension for Lily, and 99% on errors and 100% on comprehension for Luna. See Table 4.

Table 4
*Median Oral Reading Scores for All Participants*

<table>
<thead>
<tr>
<th></th>
<th>WPM</th>
<th>Errors</th>
<th>Comp</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alec</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>113.1</td>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>iPad</td>
<td>95.9</td>
<td>2.5</td>
<td>85</td>
</tr>
<tr>
<td>VM</td>
<td>103.1</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td><strong>Lily</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>85.1</td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td>iPad</td>
<td>87.1</td>
<td>2.5</td>
<td>90</td>
</tr>
<tr>
<td>VM</td>
<td>75.7</td>
<td>5</td>
<td>97.5</td>
</tr>
<tr>
<td><strong>Luna</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>133.1</td>
<td>7.5</td>
<td>90</td>
</tr>
<tr>
<td>iPad</td>
<td>109.7</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>VM</td>
<td>122.1</td>
<td>9</td>
<td>90</td>
</tr>
</tbody>
</table>

*Note: LP= Large Print, VM = Video Magnifier*

**Alec**

Alec participated in seventeen of eighteen oral reading assessments. One session of reading in large print was not completed because of leaving school early for an appointment. He wore corrective lenses for only 11 of 17 sessions because his glasses were broken at the end of week four. Reading rate data for Alec are shown in Figure 6.
When reading large print text, Alec would keep the paper on the table and lean over the passage. His chin would tilt down and towards his chest. The reading rate for each data session was graphed and visually analyzed. In 24 point font print, Alec had a median reading rate of 113.1 words per minute over five sessions. Visual analysis of level and trend was hindered by the lack of data in week four. The absolute and relative changes were calculated to determine the level change within the same condition. The absolute change was determined by identifying the first and last data points and by subtracting the smallest number from the largest number. The relative change was calculated by identifying the median of the first half of the data points, identifying the median score from the last half of the data, and then subtracting the smallest median value from the largest median value. The absolute level change for reading rate increased by 13.6 wpm, and the relative change increased by 16.3 wpm. Based on the existing data, the level indicated a stable level and a gradual improving acceleration trend line over time. All five data points fell within the stability envelope.

![Alec's Reading Rate](image)

*Figure 6. Alec’s reading rate by reading medium.*
When reading on the iPad, Alec placed the iPad on the table. His viewing distance varied between six and eight inches. He leaned over the iPad and tilted his chin down as he read. Typically, Alec would use his right pointer finger to move the text back and forth but did also use his left pointer finger. He maintained a text size of .5 cm and a screen brightness of 50%. The text was black on a white background.

On the iPad, Alec had a median reading rate of 95.9 words per minute on oral reading passages across six sessions. A visual analysis of Alec’s iPad reading data showed a stable level for words per minute over time. The absolute level change increased by 9.2 words per minute, and the relative change slightly increased by 2.3 words per minute. The trend direction showed an improving acceleration trend over time. The variability of the data points was stable over time.

Using the video magnifier, Connect 12, Alec maintained an upright posture and a viewing distance of 12 to 14 inches. He magnified the text to 0.8 cm with a screen brightness of 100%. The text was black on a white background. Also, Alec moved the paper underneath the camera to read the passage.

Alec had a median reading rate of 103.1 words per minute using the Connect 12. Visual analysis of the data showed variability with a stability envelope of 20.6. The absolute level change increased by 13.6 words per minute, and the relative change increased by 8.4 words per minute. There was an improving acceleration trend over time in wpm on the video magnifier. The data points had an initial stable level but showed an improving trend at week five and six. There was variability within the condition over time due to the changes in week five and six.
Lily

Lily participated in eighteen oral reading assessment passages. She wore corrective lenses for all sessions. In 38 point font, Lily read the passages on a slant board. She maintained a viewing distance of 10 to 14 inches. Lily was observed to move closer to the material periodically during the readings that errors were higher. Reading rate data for Lily are shown in Figure 7.

**Figure 7.** Lily’s reading rate by reading medium.

The reading rate for each data session was graphed and visually analyzed for the reading rate in large print. Lily’s median reading rate in 38 point font print was 85.1 wpm. The absolute level change decreased by 5.0 wpm, and the relative level change increased by 8.8 wpm. The level was stable over time. There was a gradual improving acceleration trend line over time. As for stability, all data points fell within the stability envelope.
When reading on the iPad, Lily held the iPad downward on an angle. The viewing distance was approximately 10 inches. Lily increased the size of the text to 0.9 cm and set the screen brightness to 100%. The text was black on a white background.

On the iPad, Lily’s median reading rate was 87.1 wpm. The visual analysis of the reading rate outcomes showed a variable level and stability. The range of data points went from 67.2 wpm to 109.7 wpm within the condition. The absolute level change increased by 12.0 wpm, and the relative change increased by 27.7 wpm. The visual analysis also demonstrated a variable trend in words per minute over time. Half of the data points fell within the stability envelope of seventeen.

When reading on the Connect 12, Lily maintained an upright posture and a viewing distance of 14 to 16 inches. She would move the paper underneath the camera and occasionally use her finger to move across the line as she read. Lily increased the text size to 0.5 cm and set the screen brightness to 100%. The text was black on a white background.

Her median reading rate on the Connect 12 was 75.7 wpm. Visual analysis of the results showed a stable level. The absolute level change increased by 13.1 wpm, and the relative change increased by 13.5 wpm. However, the trend was variable over time. The wpm would increase one week then decrease the next. The data points were stable over time.

**Luna**

Luna participated in eighteen data collection sessions. She wore corrective lenses for all sessions. In 14 point print, Lily read the passages by placing the paper flat on the table. She maintained a viewing distance of 12 to 14 inches. Luna maintained an upright posture and was observed to rest her chin on her hand periodically during the readings. Reading rate data for Luna are shown in Figure 8.
Figure 8. Luna’s reading rate by reading medium.

Luna’s median reading rate in 14 point print was 133.1 wpm. The reading rate for each data session was graphed and visually analyzed. The level and trend were variable. The absolute level change decreased by 5.9 wpm, and the relative level change decreased by 5.9 wpm. From week two through four, the wpm increased but decreased below the median for week five and six. As for stability, all data points fell within the stability envelope of 26.6.

When reading on the iPad, Luna would magnify the text to one centimeter in height with 100% screen brightness. The text was black on a white background. She would primarily keep the iPad flat on the table and tilt her chin towards her chest and appear to read over her glasses. Luna would use her right point finger or thumb to manipulate the reading passage.

The reading rate outcomes for reading on the iPad were graphed and visually analyzed. She had a median reading rate of 109.7 wpm. The level was variable with words per minute ranging from 88.8 to 128.2 wpm. The absolute change decreased by 39.4 wpm, but the relative change increased by 18.8 wpm over time. There was an improving acceleration trend with the
reading rate over time. After week three, the reading rate was higher than the median. The data varied with only four points within the stability envelope.

When reading on the Connect 12, Luna maintained an upright posture. She would magnify the text to 0.5 cm. The text was black on a white background. She was observed to tilt her chin towards her chest and appear to read over her glasses. The magnified text displayed entirely on the screen eliminating the need to move the paper back and forth when reading. She moved the paper up as she read the passage.

The reading rate outcomes for reading on the Connect 12 were graphed and visually analyzed. Luna had a median reading rate on the Connect 12 of 122.1 wpm. The level varied with reading rates from 101.7 to 143 wpm over time. The absolute change increased by 16.9 wpm, and the relative change increased by 16.2 wpm. The trend was variable especially within the last two weeks that drastically increased from the median reading rate to 134.3 and 143 wpm. The stability envelope was 24.2 and contained only four data points.

**Fluency Data by Reading Medium for Participants**

**Alec**

When reading in 24 point print, Alec’s median number of fluency errors was three. A complete visual analysis of level and trend was hindered by the lack of data in week four. In the five available data points, the error level varied from zero to seven. The absolute and relative changes were calculated to determine the level change within the same condition. The absolute change was determined by identifying the first and last data points and by subtracting the smallest number from the largest number. The relative change was calculated by identifying the median of the first half of the data points, identifying the median score from the last half of the data, and
then subtracting the smallest median value from the largest median value. The absolute level change in fluency errors increased by one error, and the relative change was zero. The trend and stability varied over time for fluency errors. Fluency data for Alec are presented in Figure 9.

![ALEC'S FLUENCY ERRORS](image)

*Figure 9. Alec’s fluency errors by reading medium.*

When reading on the iPad, Alec had a median fluency error score of 2.5 words across six sessions. The fluency error rate for each data session was graphed and visually analyzed. The level was stable. The absolute level change was an increase of five errors, and the relative change was an increase four errors. The trend direction had a deteriorating acceleration trend over time. His fluency errors increased each session over time. Five data points fell within the stability envelope.

Alec’s median errors on the Connect 12 were one across six sessions. The fluency error rate for each data session was graphed and visually analyzed. The absolute level change in fluency errors was zero, and the relative change increased by three errors. The visual analysis
showed a variable level and trend over time for fluency errors. Additionally, the data did not demonstrate stability over time.

Lily

When reading in 38 point print, Lily’s median number of fluency errors was five. The six data sessions were graphed and visually analyzed. The level varied with errors ranging from zero to eight based upon the six data points. The absolute level change in fluency errors increased by five errors, but the relative change was zero. The trend and stability varied over time for fluency errors. Fluency data for Lily are presented in Figure 10.

![LILY’S FLUENCY ERRORS](image)

*Figure 10.* Lily’s fluency errors by reading medium.

When reading on the iPad, Lily’s median error rate was 2.5. The six data sessions were graphed and visually analyzed. The absolute and relative level change in fluency errors increased by one error. However, the overall level and trend were initially stable but became variable over time. Also, the majority of the data points did not fall within the stability envelope.
Lily’s median fluency errors on the Connect 12 was five. The six data sessions were graphed and visually analyzed. The level varied from three to nine errors. The absolute level change increased by one error, and the relative level change in fluency errors increased by two errors. The trend was variable but demonstrated an overall increase over time. Only half of the data points fell within the stability envelope.

**Luna**

When reading in 14 point print, Luna’s median number of fluency errors was 7.5. The six data sessions were graphed and visually analyzed. The level varied ranging from seven to 14 errors based upon the six data points. The absolute and relative level change in fluency errors both increased by one error. The trend and stability varied over time for fluency errors. The errors were stable in weeks one and two, spiked in weeks three and four, then returned close to the median level in weeks five and six. Fluency data for Luna are presented in Figure 11.

![Luna's Fluency Errors](image)

*Figure 11. Luna’s fluency errors by reading medium.*
On the iPad, Luna’s median fluency score was six errors. The six data sessions were graphed and visually analyzed. The absolute level change in fluency errors increased by three errors, and the relative level change increased by two errors. The visual analysis demonstrated a level and trend that became variable over time. Also, the majority of the data points did not fall within the stability envelope.

On the Connect 12, Luna’s median fluency score was nine errors. The six data sessions were graphed and visually analyzed. The level varied from four to 11 errors. Overall, the level, trend, and stability were variable over time. The trend initially had a deteriorating acceleration trend but became variable over time. The absolute level change increased by six errors, and the relative level change increased by three errors. The trend was variable but demonstrated an overall increase over time.

Participant Comprehension Outcomes on Curriculum-Based Measurement

Alec

For reading comprehension passages in 24 point print, Alec’s median reading comprehension score was 90%. The absolute and relative changes were calculated to determine the level change within the same condition. The absolute change was determined by identifying the first and last data points and by subtracting the smallest number from the largest number. The relative change was calculated by identifying the median of the first half of the data points, identifying the median score from the last half of the data, and then subtracting the smallest median value from the largest median value. The absolute level change in reading comprehension decreased 25%, and the relative level change decreased by 27.5%. As with the visual analysis for errors, the visual analysis for reading comprehension showed a variable level and trend over time. Using the iPad,
Alec’s reading comprehension median score was 85%. The absolute level change decreased by 25%, and the relative change decreased by 10%. The stability level and trend had a cyclical variability for iPad reading comprehension over time. On the Connect 12, the median score was 80%. The absolute level change in comprehension rate decreased by 10%, and the relative change was zero. The visual analysis revealed variability in trend and level over time for reading comprehension. Data on Alec’s comprehension rate are presented in Figure 12.

![Alec's Comprehension Rate](image)

*Figure 12. Alec’s comprehension rate by reading medium.*

Lily

When given reading comprehension passages in 38 point print, Lily had a median reading comprehension score of 95%. The absolute and relative level change in reading comprehension increased by 10%. As with the visual analysis for errors, the visual analysis for reading comprehension showed a variable level and trend over time. Five data points were within the stability envelope and were stable over time.
When reading passages on the iPad, Lily’s reading comprehension median score was 90%. The absolute level change was zero, and the relative change increased by 10%. The level was stable, but the trend line and stability were variable over time. Using the Connect 12 to read passages, Lily had a median score of 97.5%. The absolute level change in comprehension rate increased by 10%, and the relative change increased by 5%. The visual analysis revealed variability in level and trend over time for reading comprehension, while all data points demonstrated stability over time. Data on Lily’s comprehension rate are presented in Figure 13.

![LILY'S COMPREHENSION RATE](image)

**Figure 13.** Lily’s comprehension rate by reading medium.

**Luna**

When presented with reading comprehension passages in 14 point print, Luna had a median comprehension score of 90%. The absolute level change in reading comprehension decreased by 5%, and the relative change was zero. As with the visual analysis for errors, the visual analysis for reading comprehension showed a variable level, trend, and stability over time.
She increased the reading comprehension score for the first half of the data points then decreased by the same margin for the last three data sessions.

When reading passages on the iPad, Luna had a reading comprehension median score of 100%. The absolute and relative level change increased by 20%. The level and trend were variable over time, but all data points were within the stability envelope. Using the Connect 12 to read passages, Lily had a median score of 90%. The absolute level change in comprehension rate increased by 10%, and the relative change was zero. The visual analysis revealed variability in level, trend, and stability over time for reading comprehension. The trend was initially stable but became variable over time. Data on Luna’s comprehension rate are presented in Figure 14.

![Luna's Comprehension Rate](image)

*Figure 14. Luna’s comprehension by reading medium.*
Analysis of Oral Reading Fluency Errors

A fluency error analysis was conducted to determine the type of fluency errors students with low vision made during the timed oral readings. Fluency errors were categorized either as substitutions, mispronunciations, insertions, omissions, or reversals. A substitution occurred when the participant said a different word than what was in the passage. Insertion was the addition of a word into the text, and omission was the leaving out of a word from the text. Lastly, a reversal was the change in the order of words in the passage. See Table 5.

Table 5
Total of Oral Reading Fluency Errors on Curriculum-Based Measurement

<table>
<thead>
<tr>
<th></th>
<th>Substitutions</th>
<th>Mispronunciations</th>
<th>Insertions</th>
<th>Omissions</th>
<th>Reversals</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>iPad</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>VM</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>20 (48%)</td>
<td>9 (21%)</td>
<td>4 (9%)</td>
<td>9 (21%)</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>Lily</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>15</td>
<td>0</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>iPad</td>
<td>14</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>VM</td>
<td>15</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>44 (56%)</td>
<td>2 (2%)</td>
<td>18 (23%)</td>
<td>15 (19%)</td>
<td>0</td>
<td>79</td>
</tr>
<tr>
<td>Luna</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>17</td>
<td>1</td>
<td>18</td>
<td>19</td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td>iPad</td>
<td>14</td>
<td>2</td>
<td>12</td>
<td>13</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>VM</td>
<td>15</td>
<td>3</td>
<td>10</td>
<td>23</td>
<td>0</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>46 (32%)</td>
<td>6 (4% )</td>
<td>40 (27%)</td>
<td>55 (37%)</td>
<td>1*</td>
<td>148</td>
</tr>
</tbody>
</table>

Note: LP= large print, VM= video magnifier, * <1%,

Alec had a total of 42 fluency errors in seventeen oral reading assessment passages. He had eighteen fluency errors on the iPad, nine errors on the video magnifier, and 15 errors on 24 point font text. The fewest fluency errors occurred when reading on the video magnifier. The
majority of his errors (48%) were substitutions rather than mispronunciations. Douglas et al. (2004) found that students with low vision made more substitutions than mispronunciations on the NARA when compared with peers with typical sight. An equal amount of errors occurred as mispronunciations and omissions.

Lily had a total of 79 fluency errors in eighteen oral reading assessment passages. She had the most errors when reading on the video magnifier with 32 fluency errors. The fewest fluency errors were 21 when reading on the iPad. Lily had 44 errors in substitutions that constituted 56% of her errors, which is again consistent with previous research findings. She only had two mispronunciation errors but had 18 insertions and 15 omissions.

Luna had a total of 148 fluency errors on eighteen oral reading assessment passages. When reading in 14 point font, she had 56 fluency errors. In contrast, Luna had 41 fluency errors when reading on the iPad. The highest percentage of fluency errors were distributed among three primary categories. Omissions accounted for 37% of the fluency errors, substitutions consisted of 32% of fluency errors, and insertions accounted for 27% of fluency errors. Overall, Luna had the highest number of fluency errors on the oral reading passages.

Lily and Luna had the least amount of fluency errors on the iPad in contrast to Alec, who had the most fluency errors on the iPad. Luna had 10 fewer fluency errors on the iPad in comparison to the other reading mediums. Alec has the fewest fluency errors on the Connect 12, but Lily had the most fluency errors on the Connect 12. The difference for Lily between using the iPad and video magnifier was 12 fluency errors. In large print, Luna had the most fluency errors, and Lily and Alec had the second highest amount of fluency errors. For Luna, there was a 15 error difference between the use of the iPad and in large print text.
Analysis of All Study Variables

The oral reading outcomes by reading medium for all participants were analyzed. Overall, variability in reading rate, fluency errors, and comprehension rate occurred over time for all conditions and participants. There were two exceptions in the iPad condition for Alec. Alec demonstrated a stable and slightly improving trend for reading rate on the iPad. Furthermore, Alec’s fluency errors on the iPad showed a slight deteriorating trend over time. Interestingly, the trend lines for fluency errors on the iPad were similar for Lily and Luna. Lastly, when comprehension was analyzed, the participant’s comprehension rates varied over time. Overall, the study evaluated pretest and posttest reading outcomes, examined three reading outcomes for three reading mediums, and analyzed types of fluency errors. The baseline measures were intended to address threats to internal validity and to provide more comprehensive data regarding national percentile rank and reading ages in reading accuracy, comprehension, and rate in one reading medium. The NARA posttest results demonstrated a decrease in reading age, national percentile rank, and stanine in reading accuracy and comprehension compared to peers with typical sight. However, in reading rate, all participants increased by at least one year in reading rate age, national percentile rank, and stanine when compared to peers with typical sight on the posttest.

The curriculum-based assessments were administered on each reading medium to determine whether a relationship existed between the reading medium and oral reading outcomes. The median scores for reading rate indicate a difference across participants in reading rate, errors, and comprehension. None of the participants had a distinct reading media that yielded the highest median reading rate, lowest median fluency errors, and the highest median comprehension level. For example, Alec and Luna had the highest reading rate with large print text by 10 and 11 wpm respectively in their individualized critical print size, but the number of errors was higher than on
the iPad. Lily’s highest reading rate was on the iPad but only by two wpm than in large print text. For Alec, the difference from the lowest median reading rate on the iPad to large print was 17.2 wpm and a minimal difference in errors and comprehension. Lily had an 11.4 wpm difference the video magnifier to the iPad, and Luna had a 23.4 wpm difference from the iPad to large print text. The visual analysis of the oral reading outcome data over time demonstrated an overall variability within the condition and across participants in reading rates for the reading medium as shown in Figure 15.
Figure 15. Oral reading outcomes by reading medium for all participants.
CHAPTER V

DISCUSSION

Overall, across all participants, there was not a relationship between the use of large print, an iPad, or a video magnifier and oral reading outcomes. Oral reading outcomes over time varied within and across participants. Oral reading rates and near reading preferences also varied among participants in an earlier study by Lusk (2012). However, two patterns emerged for two participants within a condition. For Alec, the reading rate on the iPad had the most stable data and demonstrated a gradually improving acceleration trend across time. The data on Alec’s fluency errors was also stable but demonstrated a deteriorating acceleration trend over time. The faster he read, the more errors he made on the reading passages on the iPad. The iPad condition was the only condition with relatively constant trends but did not indicate a superior condition, bearing a similarity to the variability of oral reading rates in Lusk’s findings (2012). For Lily, the reading rate in large print was stable and demonstrated a gradually improving acceleration trend.

Alec and Luna had the highest reading rate when using large print. The print was presented in the critical print size that did not require the participants to manipulate the text. The result contrasts with the findings of McLaughlin and Kamei-Hannon, who found slightly higher reading speeds on the iPad than large print paper for high school students (2018). Age of the students, presentation of the passages, and type of reading material differed in McLaughlin and Kamei-Hannon (2018). Although Lily had the highest reading rate on the iPad, she was able to scroll back and forth across the lines and maintain magnification level with only one significant miscue. Furthermore, Lily was able to view more words on a page on the iPad than in 38 point
text. The iPad was her reading preference for the passages. In contrast, Luna was observed to lose her place on the line, accidentally decrease the magnification, and then reestablished orientation on the line on a few occasions on the iPad. Luna also preferred the iPad for reading even though she experienced those minor issues.

Fluency errors and comprehension rate were the other two oral reading outcomes investigated in the study. The iPad and video magnifier conditions were variable for Lily. For example, Lily had the highest reading rate, the lowest median number of fluency errors, but the lowest median comprehension percentage on the iPad. Luna’s data had greater variability across all conditions. The two fastest reading rates for Luna in large print text corresponded with the highest number of fluency errors but with a 100% comprehension rate. The number of fluency errors appeared to not significantly impact Lily’s or Luna’s comprehension rates over time. Lily and Luna had median comprehension scores of 90% and greater across all conditions.

Lily had the highest median comprehension score on the video magnifier across all participants, and Luna had the highest median comprehension percentage on the iPad across all participants. Interestingly, Alec had the lowest median comprehension scores, the least amount of fluency errors, and the least amount of variability in reading rate range among the participants across all conditions. He had the highest reading rate, the least amount of errors, yet the lowest median comprehension rate on the video magnifier. Generally, the comprehension rates varied by 5% to 10% among participants on the iPad or in large print text. The minimal difference is comparable to the reading comprehension outcomes on the iPad or large print paper for participants in the McLaughlin and Kamei-Hannon study.

Possible confounding factors such time of day and lighting conditions were controlled for by rotating the time of day for data collection and reading media and by using a windowless
room with overhead fluorescent lighting. A possible external factor could have been the subject or activity such as recess or specials preceding data collection. For example, Lily had returned from physical education on one weekly session and read at a faster rate with higher accuracy and comprehension from previous passages that day. Level of interest in the reading passage or level of prior knowledge regarding the reading passage topic may have contributed to lower comprehension rates among the participants.

For the overall total of fluency errors, a minimal difference in the number of errors existed between large print and the iPad for two participants, which is comparable to a previous finding. In their study, McLaughlin and Kamei-Hannon (2018) found that fluency errors were minimal between large print paper and the iPad. Luna had 15 more errors on large print text than on the iPad and fewer errors than the video magnifier, which is the device she has used the least. Luna does use large print books at school and an iPad for school and home use. The total fluency errors on video magnifier errors vary among participants. Alec has the least amount of fluency errors on the video magnifier while Lily has the highest amount of fluency errors on the device. Alec is the most familiar with the video magnifier and has a desktop video magnifier at school and home, and Lily had been introduced to a desktop video magnifier.

Miscue analysis of the CBM passages showed that participants with low vision made a higher number of substitutions than mispronunciations across all reading media. The study findings are consistent with earlier studies. When given an oral reading fluency assessment, Douglas et al. (2004) reported that children with low vision had more substitution errors than mispronunciation errors compared to sighted peers. Khalid, Buari, and Chen (2017) found that mispronunciations and substitutions were the most frequent errors made when children with typical vision read random words and contextual sentences. Substitutions constituted the highest
percentage of oral reading fluency errors for Alec and Lily, but omissions were greater than substitutions for Luna. In addition, Luna had a higher percentage of insertions and omissions than Alec and Lily. Omissions were reported to be significantly different between reading contextual sentences and random words for children with typical vision (Khalid et al., 2017). A possible explanation for the number of insertions and omissions could be attributed to weak visual tracking due to unequal refraction in both eyes. Furthermore, reading too quickly could be a contributing factor to fluency errors. During a data collection session, Luna stated that she tended to compete against herself during oral reading assessments.

On the NARA pretest, two participants had reading rates below their chronological age in comparison to sighted peers. Previous research found that children with low vision may have slower reading rates than sighted peers of the same age (Corn et al., 2002; Douglas et al., 2002; Lueck et al., 2003). Reading rate ages, national percentile rank, and stanine increased for all participants at the posttest while the accuracy and comprehension rates decreased. Even though accuracy and comprehension rates decreased for all participants, only Lily’s accuracy score fell one year behind her chronological age while the other scores remained above Alec’s and Luna’s chronological ages. Douglas et al. (2002) reported that children with low vision might have lower accuracy and comprehension scores, which applied to only one participant. The NARA comprehension rates seem to align with previous findings that reading comprehension rates for children with low vision did not significantly differ from sighted peers (Gompel et al., 2002; Gompel et al., 2004). The miscue analysis trends for participants with low vision demonstrated a higher overall number of mispronunciation errors than substitutions, which is the opposite of findings from Douglas et al., 2004. The difference could be attributed to the fewer words in the passages and the fewer number of passages presented in the NARA compared to the CBM passages.
Individual Participant Variables

Alec

Alec was not present for one of the large print data collection sessions. He did break his corrective lenses after the completion of week four. Before the study, Alec received new corrective lenses with a bifocal and was adjusting to looking through it when reading. He completed the last two weeks of data collection and posttest without corrective lenses. Regarding the NARA, Alec reached a ceiling at level five in which he did not reach the ceiling during the pretest. Overall, he was most vocal and enthusiastic about participating in the study. Alec verbalized on multiple occasions about his love of reading and enjoyed using all reading media.

Lily

Lily was not feeling well during the NARA posttest session. She requested to discontinue testing after completing the level three passage without reaching the ceiling. Lily reached the ceiling at level four during the pretest. She expressed a preference for reading on the iPad for she could magnify the text. Lily disliked the larger size of the Connect 12 and tendency of the text to become blurry when reading.

Luna

For the NARA pretest session, Luna’s recordings were unable to be reviewed by the researcher and second rater. There was a malfunction with the video storage. When reviewing her CBM reading passages, it took six hours for the researcher and second rater to review due to
the high amount of fluency errors. All passages were reviewed a minimum of two times, but a vast majority were reviewed three or more times to count the fluency errors accurately.

Luna expressed her love for reading. She remarked that she competed against herself when given the reading passages although she was not given her reading rate or the number of fluency errors. Luna preferred the iPad for reading over the video magnifier because of the ease of use. Luna said the disadvantages of using the Connect 12 was the set up and need to maintain good posture.

**Limitations**

As with any study, limitations exist in this research. Children with low vision are a heterogeneous population. The nature of single-case research design does not allow for generalizations to a broad population of children with low vision. Participants with similar ages, grades, and eye conditions were sought to increase internal validity. Two participants were in fourth grade and were nine years old, and one participant was in third grade and eight years old. Alec and Lily had a secondary eye condition of nystagmus. Alec and Luna had a primary diagnosis of congenital cataracts. Direct replication of participants was not exact but similar. One factor that changed for Alec was the absence of corrective lenses for week five and six for the study.

Oral reading outcomes may have been affected by the approach to literacy instruction and reading curriculums used at each school and grade. Each school used a different CBM measure of oral reading outcomes. To mitigate the potential differences, the researcher administered the Quality Reading Inventory to determine the independent reading level. Natural maturation may have influenced oral reading outcomes due to conducting the study at the beginning of the second quarter. To minimize any potential effect, the NARA was used as a baseline measure to
determine reading age at the beginning and end of data collection. The NARA is a test of Standard English developed in the United Kingdom. During the assessment, Luna did mispronounce one common word in British spelling versus American English. She commented on the spelling on one reading passage.

The student investigator and second rater simultaneously assessed the reading passages over three sessions. The interrater observation agreement did not utilize blind scoring due to two primary factors related to fluency errors and comprehension. At times, participants were difficult to hear on the recordings and read quickly making it more challenging for the scorers to record the errors in the first viewing accurately. Some of the responses given during the comprehension question merited discussion on whether the student gave an appropriate answer.

Furthermore, the process of assessing oral reading fluency errors for the participants should be addressed. Real-time scoring was completed by the researcher when the CBMreading COMP™ passages were given to each participant. The initial raw number of fluency errors were recorded for a total of 53 passages. Then, the audio and video recordings were reviewed by the researcher and second rater and scored. The initial raw scores and IOA scores were compared. Thirty-nine fluency error scores were corrected after viewing the recordings by the researcher. The rate of correction was 73.6% for all passages. Alec’s scores were adjusted for 35.3% of the passages, and Lily’s scores were adjusted for 83.3% of the passages. Luna had the highest rate of adjustment at 100% of the passages.

The discrepancy calls attention to the real-time assessment of oral reading fluency errors of children with low vision for this study. Two factors could impact real-time assessment scores. One factor could be the level of training on oral reading assessments of the researcher. Also, during the oral reading assessments, the researcher was noting visual behaviors and use of the
iPad and video magnifier, which required visual and auditory attention. The use of audio and video recordings significantly assisted in the identification of the fluency errors during oral reading of the CBM passages. The recordings allowed the researcher and second rater to replay the recordings to thoroughly analyze each fluency error made by the participants in addition to noting visual and motor behaviors.

The characteristics and functions of the independent variables and instrumentation should be considered. The iPad specs and features offered a higher screen resolution at 2224 x 1668 than the Connect 12 at 1920 x 1080 screen resolution. The Connect 12 tablet was larger than the iPad by 2.1 in. inches, offered an extra 1.1 in. of diagonal screen display, and a 13 megapixels Ultra High Definition (UHD) camera. The participants chose to use the iPad in portrait orientation in comparison to the set landscape orientation of the Connect 12 stand. Luna consistently chose to hold the iPad at a slight angle for the readings in contrast to Alec and Lily who had the iPad flat on the table. The iPad passages required physical magnification and scrolling of the text on the screen, and the Connect 12 required physical magnification of the text on the screen, but the movement of the paper below the camera. The Connect 12 had two technical malfunctions that resulted in the device spontaneously shutting off during the reading passage. The iPad also had two technical malfunctions in which the text was distorted on half of the passage.

The independent participants’ experiences on the iPad and Connect 12 for reading task varied between each student. All students had been exposed to a video magnifier, but Alec was the only student actively using one at school and home. Luna used a personal iPad at school in conjunction with large print books and use of a dome magnifier. Lily used large print, dome magnifier, slant board, and the iPad. She had a Visiobook but had chosen to discontinue using it. At school, Alec used the Chromebook in class to participate in activities and to complete class
assignments. Lily’s classroom did not use Chromebooks or iPads on a daily basis. Luna’s classroom did use iPads or Chromebooks for class activities. Overall, the level of exposure to technology varied among the students.

**Future Research**

As an extension, extended silent reading across reading mediums could be studied. This study examined oral reading rates given narrative passages with three hundred words or less. Participants ranged in the time they took to orally read each passage, ranging from one minute and 30 seconds to five minutes. However, throughout the school day and for homework, students may silently read passages of greater length or for a designated time. A future study could explore the relationship of large print, iPad, and video magnifier with sustained silent reading rates and comprehension.

Furthermore, a qualitative study of the user’s perspective of using reading media could be explored as suggested by the multidimensional framework of reading by Mangen and van der Weel (2016). Literature addressing the personal variables related to the use of assistive technology use by children with visual impairments has been limited. A qualitative study could examine the individual factors that may impact the use of optical aids, tablets, and laptops and preferences for particular reading media. The inclusion of qualitative measures and data would provide a comprehensive view of the relationship of digitisation on oral reading outcomes for children with low vision.

For the current study, participants navigated the reading passages in the iBook application by scrolling horizontally across the page. Additional research should examine the text manipulation and navigation of reading passages on the iPad for children with low vision.
Researchers could examine the difference between reading rates in the critical print size on the iPad versus a pdf file in iBooks or similar applications. It may provide insight into the relationship of continuous scrolling on reading rates on the iPad. Additional considerations for future research include examining polarity on reading rate and fluency for reading on an iPad or video magnifier. All participants chose to read black text on a white background on the iPad and video magnifier. Little research has been conducted on the effects of reverse polarity on reading rate for children with low vision.

**Implications for Practice**

A primary responsibility of a Teacher of Students with Visual Impairments (TSVI) is to facilitate access to educational materials for students with visual impairments. Teachers of Students with Visual Impairments may provide training on the use of low vision devices and mainstream electronic devices to access educational materials. In addition to instruction on devices, TSVIs are responsible for conducting Functional Vision and Learning Media Assessments on students who are blind and visually impaired every reassessment cycle and when changes in vision occur. It is essential to assess the individual needs of students with low vision on their primary learning media and ability to efficiently use optical and electronic devices to access print materials. Students with low vision would benefit from assessments of oral reading outcomes with standard print, critical print size, and any aids or devices. Teachers of the Visually Impaired may use video recordings of the oral reading assessments beneficial to accurately report visual reading behaviors and record fluency and comprehension errors.

School systems might have district wide technology devices for all students such as electronic tablets, Chromebooks, or laptops. The district policy of 1:1 devices for all students
may not be best suited for students with low vision. Students with low vision may make changes in reading media over time and use different devices based upon the circumstances and situations. The students need flexibility to utilize a different reading media in their toolbox to access a variety of print materials. Teachers of Students with Visual Impairments should advocate the individualized needs of their students based upon multiple data sources such as the Functional Vision and Learning Media Assessments, low vision evaluations, ophthalmological or optometric reports, and reading assessments. Students with low vision should be aware of their abilities and possible limitations across all reading media to communicate and advocate for their needs in educational settings. Self-determination is a critical component of success.

**Conclusion**

The research study examined the relationship of the iPad, video magnifier, and large print text on oral reading rate, fluency, and comprehension among three children with low vision. Across all participants, there was no functional relation between the use of an iPad, video magnifier, or large print text on oral reading outcomes. Reading rate, fluency, and comprehension varied over time for each participant in the reading medium and across all participants in the reading medium. There was not a precise reading medium with the highest reading rate, the least amount of errors, and the highest level of comprehension for each participant or across all participants when given curriculum-based measurements. External factors such as time of day were controlled for by rotating the schedule for data collection for each reading medium and time of day and changes to lighting conditions by using windowless rooms with overhead fluorescent lighting. The number of fluency errors on the iPad and on large print text was minimal for two participants but varied among participants on the desktop video magnifier. The overall miscue
analysis revealed a higher number of substitution errors than mispronunciation errors among participants.

The outcomes from the NARA pretest and posttest demonstrated a decrease in reading accuracy and comprehension for all participants. However, all participants demonstrated an increase from the pretest of at least one year in reading rate age, national percentile rank, and stanine when compared to peers with typical sight. In comparison to peers with visual impairments, all participants had a visual impairment reading rate age, accuracy, and comprehension above their chronological age. Factors contributing to the increase in reading rate were difficult to determine since no intervention was used in the study. The decrease in accuracy and comprehension and increase in rate for all participants should be further investigated.

The research study addressed an area of need for research among children with low vision as identified by Thomas et al. (2015). The study contributed to the limited literature using single-case research designs to examine the relationship of reading media on oral reading outcomes for children with low vision. Further research is needed to determine the relationship on the use of a video magnifier and the iPad on oral reading outcomes for students with low vision, particularly with sustained reading tasks.

Students with low vision make changes in reading media over time. Students may use a variety of tools to access print materials depending on the situation, lighting, contrast, and environment. One reading medium may not suit the individual needs of students with low vision. Educators should consider and assess the individual differences across reading medium for each student with low vision to determine efficient methods of accessing print materials. Consequently, students with low vision may benefit from the knowledge of their reading outcomes to make informed decisions about reading media and to advocate for reading media preferences.
Appendix A

Human Subjects Institutional Review Board Approval
Date: October 5, 2017

To: Kieran Fogarty, Principal Investigator
    Rosemary Nave Stawasz, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 17-09-18

This letter will serve as confirmation that your research project titled “The Use of iPad Accessibility Features by Children with Low Vision on Reading Outcomes” has been approved under the expedited category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 4, 2018
Date: March 8, 2018

To: Robert Wall Emerson, Principal Investigator
    Rosemary Nave Stawasz, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 17-09-18

This letter will serve as confirmation that the changes to your research project titled “The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision” requested in your memo received March 6, 2018 (to change title from “The Impact of an iPad®, a Video Magnifier, Large Print Text on Oral Reading Outcomes for Children with Low Vision” to “The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision”) has been approved by the WMU Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 4, 2018
Appendix B

Recruitment Email and Flyer
Hello! My name is Rosemary Nave Stawasz. I have joined the faculty at the University of Kentucky as a Clinical Assistant Professor in the Visual Impairment program. Also, I am a doctoral candidate at Western Michigan University. Blue Cross Blue Shield awarded me with a Student Award Grant to conduct research on the use of iPad, a video magnifier, and large print text on oral reading outcomes. The study is titled “The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision.” I seek to analyze reading outcomes such as how many words per minute students read, how well they can read and pronounce words, and comprehend what they just read on the iPad, a video magnifier, and large print text. I plan to use this study to contribute to the evidence that can be used to make educational recommendations for students with low vision.

Here’s an overview of the study:

Critical print reading size and the independent reading level will be determined for each participant. All students will be given a pretest and posttest oral reading assessment using the Neale Analysis of Reading Ability (NARA). Next, the students will use either an iPad, video magnifier, or large print text for each session reading appropriate independent level passages from an oral reading assessment. For the next session, the device and passage will be alternated. Including the pretest and posttest, students will participate in a total of 20 fifteen minute sessions. Data will be analyzed and reported to Blue Cross Blue Shield Student Award Program, the Institutional Review Board at Western Michigan University, and to research participants upon request. This study will be used for my dissertation.

I am recruiting participants

- with low vision with a visual acuity of 20/70 in the better eye with best correction or a field of 20 degrees or less to 20/400 in the better eye with best correction
- between the ages of eight and thirteen
- may have a secondary disability of autism spectrum disorder, behavioral or emotional impairment, deaf or hard of hearing, otherwise health impaired, physical impairment, specific learning disability, or traumatic brain injury
- who attend a public school or residential school
- have experience with an iPad and a video magnifier
- Students who are reading within one grade level or at grade level is preferred.

If you or someone you know are interested in learning more about participating, please call or email me. I can provide additional details and provide consent forms. Thank you for your time!

Sincerely,

Rosemary Nave Stawasz

rosemary.navestawasz@wmich.edu

269-366-8819 cell phone, 859-257-7925 office line
Research study opportunity

Background

I am a current doctoral candidate at Western Michigan University and a new faculty member at the University of Kentucky as a Clinical Assistant Professor in the Visual Impairment program. I was awarded a Blue Cross Blue Shield Student Award Grant to conduct research. The study is titled: “The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision.”

What is it about?

I am going to research reading on the iPad, reading using a video magnifier, and reading large print text by children with low vision. I will look at:

- how many words per minute students read
- overall reading fluency and
- how well they understand what they just read

Who is eligible?

Children enrolled in a school district or residential school

- with low vision from 20/70 with the best correction or a field loss of twenty degrees or less to 20/400 with best correction
- ages eight to thirteen years old
- may have a secondary disability of autism spectrum disorder, behavioral or emotional impairment, deaf or hard of hearing, otherwise health impaired, physical impairment, specific learning disability, or traumatic brain injury.
- who attend a public school or residential school
- must have experience with an iPad and a video magnifier and can independently operate both devices
- reading within one grade level or at grade level is preferred

How will the study work?

- All those who are interested in learning more will receive a consent form outlining the details of the study.
- If you agree, I will contact you to discuss the study with the child and obtain permission to participate. I will contact the school administrator, discuss the study, and obtain permission to be in the study.
If you have any questions, please feel free to contact me! Thank you for your time.

Sincerely,

Rosemary Nave Stawasz
rosemary.navestawas@wmich.edu
(269) 366-8819 cell phone
(859) 257-7925 work phone
Appendix C

Site Approval Letters
To Whom It May Concern,

I have been contacted by Rosemary Nave Stawasz, a Clinical Assistant Professor at the University of Kentucky and Doctoral Candidate at Western Michigan University to conduct a research study. The title of the research study is “The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision”. The research study proposes to examine oral reading outcomes for children with low vision when reading passages on an iPad, reading passages using a video magnifier, and reading large print text. The study will analyze reading outcomes such as reading rate, fluency, and comprehension.

First, the student investigator will recruit potential participants for the study by contacting Teachers of the Visually Impaired (TVIs) and Special Education Service Region Consultants by email. A flyer will be attached to the email for the TVIs and Consultants to distribute to families. The TVIs and Consultants will only serve to distribute the flyers to families. Any interested families will directly contact Rosemary Nave Stawasz. Once a potential participant is identified, Rosemary will provide the school with a site approval letter. After approval is obtained, the school will provide information regarding the student’s special education eligibility label of visual impairment, the presence of a secondary disability, age, grade, reading level, and teacher(s).

For the study, the student participant(s) will be removed from class by the student investigator. First, the student investigator will assess the participants’ critical print reading size using the MNREAD app and independent reading level using the Quality Reading Inventory. Next, the student participant(s) will be asked to read a passage from Form 1 of the Neale Analysis of Reading Ability (NARA) on an iPad, a video magnifier, and in large print text. Then, the student(s) will be assessed by a TVI on oral reading rate, fluency, and comprehension on an iPad, a video magnifier, and large print text for twenty sessions using various oral reading assessment passages. The student investigator will videotape and collect data on oral reading rate, fluency, comprehension, settings on the iPad, video magnifier, large print text size, and viewing distance. The time commitment will be six weeks for twenty 15-minute sessions for a total of 300 minutes. Data collected and videotape recordings will be confidential, de-identified, and stored in a locked cabinet in the office of Rosemary Nave Stawasz during the study and transferred to Western Michigan University upon completion of the study.

The student will have an opportunity to use an iPad, video magnifier, and large print text. The research study may assist in choosing technology devices that are research based on maximizing oral reading outcomes. The oral reading outcomes may be shared with the teacher. Lastly, the school may receive a copy of the study results.
If any questions arise, I may contact student investigator, Rosemary Nave Stawasz, at 269-366-8819, 859-257-7925, rosemary.nave.stawasz@uky.edu or the primary investigator, Dr. Rob Wall Emerson at 269-387-3072 or robert.wall@wmich.edu.

I have read and consent to the conditions of the study. I grant permission for the research study to occur at this site.

Sincerely,

Name and Title
Appendix D

Informed Consent Letter
Western Michigan University
Department of Interdisciplinary Health Sciences

Principal Investigator: Robert Wall Emerson, Ph.D.

Student Investigator: Rosemary Nave Stawasz, M.A.

Title of Study: The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision

Your child has been invited to participate in a research project entitled “The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision.” The purpose of the study is to examine and compare reading outcomes (reading rate, fluency, and comprehension) among children with low vision using the iPad, a video magnifier, and large print text. This project will be used for the student investigator’s dissertation.

What are we trying to find out in this study?
The investigators seek to look at oral reading outcomes for children with low vision when reading on an iPad in comparison to reading on a video magnifier and using large print text.

Who can participate in this study?
Children who meet the following criteria:

- with low vision from 20/70 with the best correction or a field loss of twenty degrees or less to 20/400 with the best correction
- ages eight to thirteen years old
- may have a secondary disability of autism spectrum disorder, behavioral or emotional impairment, deaf or hard of hearing, otherwise health impaired, physical impairment, specific learning disability, or traumatic brain injury.
- who attend a public school or residential school
- must have experience with using iPad and a video magnifier and can independently operate both devices
- reading within one grade level or at grade level is preferred

Where will this study take place?
The study will occur at the participant’s school.

What is the time commitment for participating in this study?
The time commitment is 15 minutes for twenty sessions. The total time commitment is 300 minutes.

What will you be asked to do if you choose to participate in this study?
First, site approval from the school administrator will be requested. The school administrator will know that a child is participating in the study. First, your child’s critical print reading size and the independent reading level will be assessed. A pretest assessment will be given by asking your
child to read aloud a passage from the Neale Analysis of Reading Ability (NARA) on an iPad, on a video magnifier, and in large print text. Then, your child will read various reading passages at an appropriate level from an oral reading assessment tool for 18 sessions. For each session, the use of the iPad, video magnifier, and large print text will be alternated each session to read the passages. At the conclusion, a posttest oral reading passage from NARA will be given on the iPad, video magnifier, and large print text. Your child will be videotaped when the oral reading passages are administered. Participation will total 20 fifteen minute sessions.

**What information is being measured during the study?**
The following information will be measured: oral reading rate, oral reading fluency, comprehension, visual behaviors, and viewing distance to the screen or paper.

**What are the risks of participating in this study and how will these risks be minimized?**
The only risks anticipated are minor discomforts typically experienced by children when they are being tested such as boredom, fatigue, irritation, or performance stress. All of the usual methods employed during standardized testing to minimize discomforts will be employed in this study. As in all research, there may be unforeseen risks to your child. If an accidental injury occurs, appropriate emergency measures will be taken. However, no compensation or treatment will be made available to your child or me except as otherwise specified in this permission form.

**What are the benefits of participating in this study?**
Although there may be no immediate benefits to your child for participating, there may eventually be benefits to students with low vision in the future. The research study may assist in choosing technology devices that are research based on maximizing oral reading outcomes.

**Are there any costs associated with participating in this study?**
There are no costs associated with participating in this study.

**Is there any compensation for participating in this study?**
There will be a $10 gift card after one completes the study.

**Who will have access to the information collected during this study?**
All assessment data and information will remain confidential. The video recordings will be viewed by the student investigator and research assistant for data analysis. Only the student and principal investigators will have access to information collected during the study. Data collected will be stored in a locked office during the duration of the study. The videotape recordings will be stored on an SD card labeled with a number code in a locked drawer in a locked office of the student investigator at the University of Kentucky. Upon the close of the study, data collection documents and SD cards will be transported and stored in a locked file at Western Michigan University for three years.

**What if you want to stop participating in this study?**
You may withdraw your child from this study at any time without any negative effect on services to your child. You will not suffer any prejudice or penalty by your decision to stop your
participation. You will experience NO consequences either academically or personally if you choose to withdraw from this study. If you have any questions or concerns about this study, you may contact either Rosemary Nave Stawasz at 269-366-8819 or Dr. Rob Wall Emerson at 269-387-3072. You may also contact the chair of the Human Subjects Institutional Review Board at 269-387-8293 or the vice president for research 269-387-9298 with any concerns that you have.

This permission document has been approved for use for one year by the Human Subjects Institutional Review Board as indicated by the stamped date and signature of the board chair in the upper right corner. Do not permit your child to participate if the stamped date is more than one year old.

Your signature below indicates that you, as parent or guardian, can and do give your permission for _______________________ (child's name).

• to participate in the study
• to be videotaped when reading passages aloud
• to be tested with Neale Analysis of Reading Ability
• to participate in 20 sessions
• to report this information to the child’s teachers to assist in educational programming

____________________________
Parent or Guardian Signature

____________________________
Date

Consent obtained by: ______________________________
Appendix E

Assent Form
Western Michigan University  
Department of Interdisciplinary Health Sciences

Principal Investigator: Robert Wall Emerson, Ph.D.  
Student Investigator: Rosemary Nave Stawasz, M.A.  
Project Title: The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision

**What are we trying to find out in this study?**  
I am doing a research study. A research study is a special way to find out about something. I want to find out if an iPad, a video magnifier, and large print text affects how many words you can read in a minute, how easily you can read the passage, and how you remember what you read.

**Who can participate in this study?**  
Children between the ages of 8 and 13 with a documented visual impairment with a visual acuity of 20/70 or worse or restricted visual fields. You may have a secondary special education label like a specific learning disability. You can attend a residential school or public school. Also, you must have used an iPad and a video magnifier before and can use it by yourself.

**Where will this study take place?**  
It will happen at school.

**What is the time commitment for participating in this study?**  
20 sessions for fifteen minutes each. The study will be six weeks.

**What will you be asked to do if you choose to participate in this study?**  
If you want to be in this study, you will be asked to read passages aloud and answer comprehension questions. You may read it using a video magnifier, an iPad, and large print text. You may be videotaped.

**What information is being measured during the study?**  
Information about how you read like how many words in a minute, how you read the words, and how well you understood what you read.

**What are the risks of participating in this study and how will these risks be minimized?**  
You may miss some class time and instruction to do the readings. You may not like to do the readings and may get frustrated or tired. You can be given breaks for fatigue.

**What are the benefits of participating in this study?**  
If you decide to be in this study, some good things might happen to you. You may figure out whether the iPad, a video magnifier, or large print text is easier to read on. It may help you decide what works better for you when reading. But we don’t know for sure that these things will happen. We might also find out things that will help other children someday.
Are there any costs associated with participating in this study?
There are no costs for participating.

Is there any compensation for participating in this study?
Yes, at the completion of the study, you will be given a $10 gift card.

Who will have access to the information collected during this study?
The primary investigator and student investigator will only have access. When we are done with the study, we will write a report about what we found out. We won’t use your name in the report. We may share the results of the oral reading assessment with your teacher.

What if you want to stop participating in this study?
You don’t have to be in this study. You can say “no”, and nothing bad will happen. If you say “yes” now, but you want to stop later, that’s okay too. No one will be mad at you or punish you if you want to stop. All you have to do is tell us you want to stop.

If you have any questions or concerns about this study, you may call either Rosemary Nave Stawasz at 269-366-8819 or email at rosemary.navestawasz@wmich.edu or contact Dr. Rob Wall Emerson at 269-387-3072 or at robert.wall@wmich.edu.

The stamped date and signature of the board chair in the upper right corner means this consent document is approved for use for one year by the Human Subjects Institutional Review Board. Do not participate if the stamped date is more than one year old.

If you want to be in this study, please sign your name.

I, ________________________________________, want to be in this research study.
(Write your name here)

______________________________________________

Witness Date
Appendix F

Video Use Permission Form
Video Use Permission Form
Western Michigan University

Principal Investigator: Robert Wall Emerson, Ph.D.
Student Investigator: Rosemary Nave Stawasz, M.A.
Project Title: The Relationship of an iPad, a Video Magnifier, and Large Print Text on Oral Reading Outcomes for Children with Low Vision

As a participant in the dissertation research project, videotape recordings of your child will be made during your child’s participation in the study. The student investigator will videotape each oral reading assessment session and view the recordings with a research assistant to conduct data analysis of the oral reading rate, fluency errors, comprehension, and visual behaviors. There will be twenty videotape recordings of your child reading on an iPad, a video magnifier, and in large print. The videotape recordings will be placed on an SD card labeled with a number code and kept in a locked cabinet in the locked office of the student investigator at the University of Kentucky during the study.

Please indicate below what uses of this recorded material you consent to allow us to use for scientific purposes. Please place a check mark by all that are applicable. Your responses will not affect your participation in the study, and the recordings will only be used in a way that you agreed to by the check marks indicated. You will not be identified by name with the recordings.

If you do not initial any of the spaces below, recordings of you will be destroyed.

Please indicate the type of informed consent

☐ Videotape

☐ The videotape can be analyzed as part of the research project.
Please initial: ______

☐ The videotape can be used for publication in scientific journals.
Please initial: ______

☐ The videotape can be shown as part of a presentation given at a scholarly conference.
Please initial: ______

☐ The videotape can be shown in courses to undergraduate or graduate students studying visual impairment.
Please initial: ______
I have read the above description and give my consent for the use of the videotape as indicated above. I understand that the recordings will not be used for any purposes other than those I have indicated above.

Printed Participant Name ____________________________

SIGNATURE ____________________________ DATE ________________
Appendix G

MNREAD Sample Sentence
The old man caught a fish here when he went out in his boat
Appendix H

Copyright Permission for Hasbrouck & Tindal (2017)
Dr. Hasbrouck,

Hello! After consulting the dissertation guidelines for Western Michigan University, I needed to add a section regarding ProQuest Information and Learning into the request. Here is my revised formal request. An email response will be sufficient to include as a copy in the appendices. Thank you again for your assistance and permission!

--

Dear Dr. Hasbrouck,

I would like to request permission to include an excerpt from the following item in my dissertation:


I am seeking to use Figure 4. The Compiled ORF Norms 2017 (grade 3 and 4 norms) for my dissertation. My dissertation study was on oral reading outcomes for children with low vision when reading in on an iPad, a video magnifier, and in large print text. The source will receive full credit in the manuscript.

By agreeing to the use of the item in my dissertation, you give ProQuest Information and Learning (PQIL) the right to supply copies of this material on demand as part of my doctoral dissertation. Please attach any other terms and conditions for the proposed use of this item.

If you no longer hold the copyright to this work, please indicate to whom I should direct my question. Please contact me if you have any questions. Thank you for the consideration and attention to this matter.

--

Jan Hasbrouck <janhasbrouck@gmail.com>
Sent: Thursday, May 9, 2019 8:31:00 PM
To: Rosemary, Rosemary <rosemary.nave.stawasz@uky.edu>
Cc: Steffani L Mast <stefani@uoregon.edu>
Subject: Permission to use norms

Rosemary, you certainly have our permission to use the Hasbrouck & Tindal norms (2017). If there's more formal paperwork you need for me to complete, just let me know.

Best,
Jan
Rosemary.


Best of luck with your work.

Jan

Jan Hasbrouck, Ph.D.

Gibson Hasbrouck & Associates
www.gha-pd.com
C: 208-436-0123
@janhasbrouck
Appendix I

NARA Form 1
# Neale Analysis of Reading Ability – Second Revised British Edition

**Individual Record**

<table>
<thead>
<tr>
<th>Name</th>
<th>School</th>
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<table>
<thead>
<tr>
<th>Date of birth</th>
<th>Date of testing</th>
<th>Age at testing</th>
<th>Year group</th>
<th>Language(s) at home</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yrs Mths</td>
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</table>

<table>
<thead>
<tr>
<th>Test administrator</th>
<th>Class teacher</th>
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<tbody>
<tr>
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<td></td>
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</tbody>
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## RAW SCORE SUMMARY

<table>
<thead>
<tr>
<th>Passage</th>
<th>Maximum score</th>
<th>Number of errors</th>
<th>Accuracy score</th>
<th>Number of correct answers</th>
<th>Number of words</th>
<th>Time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Bird</td>
<td>16</td>
<td>-</td>
<td></td>
<td>[26]</td>
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<tr>
<td>Level 2 Road Safety</td>
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<table>
<thead>
<tr>
<th>Total number of words in passages read</th>
<th>Total time</th>
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</thead>
<tbody>
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</tbody>
</table>

**TOTAL RAW SCORES**

<table>
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<tr>
<th>Words per minute:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of words</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
</tbody>
</table>

*Words per minute: = Total number of words ÷ Total time x 60 = x 60.*

- Rates: use only those passages that were actually read by the child.
- Last passage read: where the permissible percentage of error is exceeded do not use that passage in any calculation.
- Basal level: credit further passages fully for accuracy (i.e., score 16 for passage score) and comprehension (i.e., 4 for Level 1 and 8 for Level 2 and above).

Directions for administering and scoring this form may be found on page 5 of the Manual.

## STANDARDIZED SCORE SUMMARY

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<td></td>
<td></td>
</tr>
<tr>
<td>68% CONFIDENCE BAND</td>
<td>to</td>
<td>to</td>
<td>to</td>
</tr>
<tr>
<td>STANDARDIZED SCORE</td>
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<td></td>
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<tr>
<td>68% CONFIDENCE BAND</td>
<td>to</td>
<td>to</td>
<td>to</td>
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<tr>
<td>NATIONAL PERCENTILE RANK</td>
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## ERROR COUNT

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<th>Substitutions</th>
<th>Refusals</th>
<th>Additions</th>
<th>Omissions</th>
<th>Reversals</th>
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</thead>
<tbody>
<tr>
<td>% of total count*</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Error count x 100 / Total count
Appendix J

NARA Reading Passage Level 1
A bird hopped up to my window.

I gave her some bread.

She made a nest in my garden.

Now I look after her little ones.
Appendix K

NARA Reading Passage Level 3
As Ali sheltered in an old temple, his shoulder knocked a secret spring. Instantly, he was thrown into an underground room.

In the darkness the walls seemed to be covered with jewels. Ali rested awhile. He knew that desert travellers often imagined strange things.

Later, he explored the place for a way to escape. To his amazement, the jewels were still there. He had found a palace that had been buried long ago.
Appendix L

FastBridge Copyright Permission
Rachel Brown <rachel@fastbridge.org>
Mon 10/15/2018 1:03 PM
Rosemary Louise Nave Stawasz

Rosemary,

My apology for not getting back to you sooner. For some reason the automatic notification feature of the form got turned off so I did not see your submission. I am glad you contacted me. Yes, you can have access to the FAST assessments you requested for your study. One question is whether you need access to the online administration and scoring features or if you envision using our downloadable paper forms for all study conditions. If you just need the forms, I can send them to you as attachments.

Rachel

---

Rosemary Louise Nave Stawasz
Mon 10/15/2018 10:12 AM

Dr. Brown,

Good morning! I submitted the request for FastBridge CBM passages to use for my dissertation study with children with low vision. I understand time is needed to review the request and provide feedback. Since I am unfamiliar with the process at FastBridge, could you provide a general timeline for review and feedback? It would be greatly appreciated. Thank you for your time and consideration.

Rosemary Nave Stawasz
Ph.D. Candidate
Interdisciplinary Health Sciences
Appendix M

FastBridge CBMreading COMP™ Passage
Jenny, Suzy, and Bean

One day Jenny’s class adopted a rabbit as the class pet. All the students loved watching the rabbit eat and play. Jenny asked her mom if she could get a rabbit too, but her mom said no. Their apartment was too small and rabbit cages are too big. Besides, rabbits need lots of room to move around. A rabbit could not move much in their apartment.

Jenny was disappointed, but she learned a hamster would work instead. Hamsters are like mice, but their tails are shorter, and they can store food in pouches in their cheeks. Her friend Suzy got a hamster for her birthday. It was so small, the cage fit into Suzy’s room. The hamster also had a plastic ball. The ball allowed it to run around on the floor. It would not get lost, and it could get exercise.

Jenny thought the hamster was even cuter than a rabbit. She asked her mom if they could get a hamster instead of the rabbit. Her mom said yes, and Jenny was very happy. She understood that it would be her responsibility. At the pet store, she picked out a gray hamster. It fit in the palm of her hand. She named her pet Bean because he looked like one.

Jenny set up Bean’s cage and gave him food and water. She played with him every day, and he loved running in his ball all around the house. Jenny was very glad to have a new pet.
Appendix N

Data Collection Schedule
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National Reading Panel & National Institute of Child Health and Human Development. (2000).


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10.1111/opo.12379


