COMPREHENSION SCORES AMONG YOUTH TYPICALLY DEVELOPING CHILDREN
AND CHILDREN WITH AUTISM: TRADITIONAL AND TABLET-BASED STORYBOOKS

A Dissertation by

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To the children with autism and their vocabulary-age matched peers who participated in this study.
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ABSTRACT

Research involving assessments and interventions incorporating technology for children with autism is considered a new area of science. The purpose of the current study was to (a) investigate potential differences between paper and tablet device presentation of a receptive vocabulary test (Peabody Picture Vocabulary Test (PPVT)) when administered to young children with autism and their vocabulary age-matched peers and (b) determine if differences exist between children’s answers to story comprehension questions from three different storybook modalities including paper and two iPad® presentations of stories. Participants (not based on classification) performed best on story comprehension questions when the story was presented via iPad® compared to traditional, paper book. These findings suggest that young children may perform better on story comprehension questions when the story is presented on the iPad®. Additionally, the findings from this study may be important to parents and educational professionals as they decide whether to use traditional, paper materials or iPad®s when presenting assessments and books to children.
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# ABBREVIATIONS LIST

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<tr>
<td>AAC</td>
<td>Augmentative Alternative Communication</td>
</tr>
<tr>
<td>ASD</td>
<td>Autism spectrum disorders</td>
</tr>
<tr>
<td>$d$</td>
<td>Cohen’s $d$, effect size</td>
</tr>
<tr>
<td>e.g.</td>
<td>For example</td>
</tr>
<tr>
<td>F</td>
<td>F value</td>
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<tr>
<td>ICC</td>
<td>Intra Class Correlation</td>
</tr>
<tr>
<td>i.e.</td>
<td>Such as</td>
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<tr>
<td>iOS</td>
<td>iPhone/iPad operating system</td>
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<td>IRB</td>
<td>Institutional Review Board</td>
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<tr>
<td>MANOVA</td>
<td>Multivariate Analysis of Variance</td>
</tr>
<tr>
<td>MS</td>
<td>Mean square</td>
</tr>
<tr>
<td>$n$</td>
<td>Number</td>
</tr>
<tr>
<td>$\eta^2$</td>
<td>Eta squared</td>
</tr>
<tr>
<td>$\eta^2_p$</td>
<td>Partial eta squared</td>
</tr>
<tr>
<td>PI</td>
<td>Primary Investigator</td>
</tr>
<tr>
<td>$p$</td>
<td>Probability value</td>
</tr>
<tr>
<td>®</td>
<td>Registered trademark</td>
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<tr>
<td>SLP</td>
<td>Speech-Language Pathologist</td>
</tr>
<tr>
<td>SS</td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>$t$</td>
<td>t-test</td>
</tr>
<tr>
<td>TOM</td>
<td>Theory of Mind</td>
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<tr>
<td>∧</td>
<td>Wilks’ Lambda multivariate test statistic</td>
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CHAPTER I

Introduction

Learning to read in the technologically infiltrated 21st century is very different from learning to read prior to the advent of personal technology such as mobile devices. Today, many preschoolers are learning how to tap pictures on screens and swipe to turn the page while simultaneously learning to point to pictures in traditional storybooks and turn the page with more hand movements than a swipe. In both cases, much of what children learn about reading is unintentional and fortuitous prior to school entry (Iran-Nejad, McKeachie, & Berliner, 1990). This incidental learning occurs within the child’s natural environment. In fact, “long before formal instruction, children use legitimate reading and writing behaviors as an integral part of their everyday lives” (Neuman & Roskos, 1997, p. 29).

These 21st century changes to preschoolers’ natural learning environments can be advantageous for children with special needs, particularly children diagnosed with autism whose attention to visual stimuli is unique. For purposes of this paper, the terms autism, autism spectrum disorder, and ASD will be used interchangeably.

Autism is characterized by restricted, repetitive behaviors; difficulties with social interaction, and differences in verbal and nonverbal communication skills (Prelock, 2006). Criteria for diagnosis of autism include two categories, social communication/social interaction, and restricted, repetitive patterns of behavior, activities, and interests (American Psychiatric Association, 2013; Zenko, 2014). The term spectrum is used because within these characteristics a range of symptoms can occur (Zenko, 2014).

Children with autism display a relative strength in processing visual stimuli and using visual information in advantageous ways (American Speech Language Hearing Association,
Additionally, research has indicated the visual aspects of technology align with the visual processing assets in ASD (Shane & Albert, 2008). Because of this alignment, many clinicians and educators are using mobile technology tools such as the iPad® for a variety of purposes, one of which is literacy learning. Furthermore, a fascination with electronics and the ability to “tune out” (Shane & Albert, 2008, p.1504) other distractions while engaged in the electronic media have been cited clinically as influencing factors for selecting the iPad® as a treatment tool, but few empirical studies in this area exist. This fascination allows children with ASD to readily interact with the iPad® and other iOS devices without (or with very little) instruction relative to their operating features (Caron & Shane, 2014).

Given the availability of and fascination with the iPad®, standardized assessments are now being transferred to iPad® format. While these assessments are easy for educational professionals to obtain, more research is needed regarding their use (Buhr, Stricklin, Jones, & Nyquist, 2016). Current research has investigated a limited range of assessments using the iPad®, and more information is needed regarding benefits and limitations of their use with children with ASD.

Strengths in visual processing skills assist children with ASD in the print processing aspects of reading such as decoding, recognizing sight words, and understanding syntax (ASHA, 2006; Whalon, Al Otabia, & Delano, 2009). Although there is a dearth in the literature regarding the print processing skills in young children with ASD, this is considered a relative strength for this population as demonstrated in the available research (Koppenhaver & Erickson, 2009; Carnahan and Williamson, 2010).
While print processing is a strength, most students with ASD have difficulty with story comprehension (ASHA, 2006; Koppenhaver, 2010; Nation, Clarke, Wright, & Williams, 2006), potentially due to difficulty in knowing the meaning of important vocabulary, understanding story schema, and making inferences (Carnahan and Williamson, 2010; Whalon et al., 2009). In the largest study to date of story comprehension skills in students with ASD, Nation, et al. (2006) found 65% of their sample ages six to fifteen years had reading comprehension scores that were at minimum, one standard deviation below norms of the population.

With limited story comprehension skills, children with ASD are at risk of developing into adults lacking literacy skills necessary to be successful in society. Literacy skills are essential in achieving self-sufficiency (Travers et al., 2011), even in the current technological age, these skills are needed to purchase groceries and household items, to order from restaurant menus, to send e-mail and text messages, and to decipher messages received.

Statement of the Problem

Reading comprehension research for individuals with ASD is approximately 30 years behind reading research for typically developing children (Koppenhaver, 2010). The research that does exist indicates both teacher facilitated (traditional) and technology assisted instruction are beneficial for teaching various literacy skills to children with ASD. In general, technology use for children with ASD is a relatively “young science” (Ennis-Cole, 2015, p. 38) with much yet to be explored. According to the National Autism Center’s Standards Report Phase 2 (2015), technology interventions are considered to be “emerging” rather than “established” treatment approaches. Under the National Autism Center’s criteria, emerging treatments might be advantageous, and further research is needed to confirm such outcomes. The Center’s Phase 1
Report (2009) demonstrated technology-based interventions have been effective for improving academic, communication, personal responsibility, and self-regulation skills.

Given evidence-based practice and the National Autism Center’s Standards Report Phase 2 (2015), some researchers suggest technology be used concurrently with other instructional procedures (Ernest et al. 2014; Knight, McKissick, & Saunders, 2013). However, the research available is limited and further research is needed to provide conclusive information (Travers et al., 2011).

Purpose

The purpose of this study was to investigate potential differences between paper and tablet device presentation of assessment protocols through answering the following: (a) do children with autism score higher on receptive vocabulary when the test is presented via a tablet rather than in paper format; (b) does a difference exists in receptive vocabulary scores when the test is administered via tablet between children with autism and vocabulary-age-matched peers; (c) are there differences in comprehension scores between children of different classification (vocabulary-age matched versus children with ASD) (d) is there a difference in comprehension scores when children in both groups are read to with a different modality (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and a traditional paper book)? (e) is there a difference in how children with different classifications responded to the varying modalities, that is does an interaction exist between modality of book reading and child classification?
CHAPTER II

Literature Review

Development of early literacy skills is imperative to later literacy development, participation in work environments, and in a broader sense, being a contributing member of society (van den Broek, Kendeou, & White, 2009). However, many children in the United States struggle with literacy skills as 33% percent of fourth graders and 25% percent of eighth graders are unable to read at a basic level (National Center for Education Statistics (NCES, 2009), and these difficulties may continue into adulthood. Therefore, it necessary for researchers to evaluate alternative approaches for assisting children to develop literacy skills.

Given the proliferation of technology in both home and school environments (van den Broek, Kendeou, & White, 2009; Ernest et al., 2014), one approach being studied for literacy learning is the use of computer and tablet technology. What is not widely researched to date, is the use of technology for young children and children with ASD (Ennis-Cole, 2015). Before exploring this topic, it is essential to have an understanding of literacy development in both typically developing children and children with ASD.

In the first section of this chapter, discussion of early literacy development will include information regarding literacy socialization, predictors of literacy success, inside-out and outside-in skills, story schema, inferencing, and essential language and literacy skills. Section two provides a description of young children’s interest in literacy through technology followed by a section detailing characteristics of autism and the implications of these characteristics upon literacy development. The fourth section outlines strengths of children with ASD including visual strengths, positive response to a predictable, structured environment, and an interest in technology. This chapter concludes with explanations of evidence of the advantages of using
technology for literacy learning in preschool children who are typically developing and preschool children with an autism diagnosis.

**Literacy Socialization**

“The home literacy environment is a critical factor in understanding children’s emergent literacy development” (Stone, Silliman, Ehren, & Wallach, 2013, p. 192). Within this home environment, from ages two to six, children attain emergent literacy skills predominately through “literacy socialization” (Kamhi & Catts, 2012). van Kleeck and Shuele (1987) outline three components of literacy socialization: literacy artifacts, literacy events, and literacy knowledge obtained by children during literacy experiences. Literacy artifacts are materials available in the child’s home such as alphabet blocks, books, T-shirts with logos, and magazines. While literacy artifacts are vital for early literacy development, literacy events and knowledge obtained by children are of greater importance.

van Kleeck and Schuele (1987) suggest literacy knowledge is obtained through membership in a literate society. This knowledge occurs through literacy events and artifacts prior to children learning to read themselves. In addition, van Kleeck and Shuele underscore involvement in literacy events and exposure to literacy artifacts help children understand the relationship between print and oral language. By observing their family members, children learn about the multiple functions of print including reading for leisure, learning new information, sending messages, and using print in daily tasks such as paying bills, writing grocery lists, looking at store ads, and reading recipes. These daily tasks are considered literacy events.

Heath (1982) defined literacy events as “occasions in which language is integral to the nature of participants’ interactions and their interpretative processes and strategies” (p. 50). Examples of literacy events include participating in games and songs, looking at alphabet letters
on food packages in the kitchen, and seeing print on road signs. According to Heath, during these events, participants follow social rules and express their knowledge about written text.

Other joint family events such as watching educational TV shows encourage literacy socialization as well. Paul and Norbury (2012) proposed that watching TV shows such as *Sesame Street*, *Blue’s Clues*, and *Arthur* give information about letter sounds, the structure of books, and the purposes of writing. Likewise, Neuman (2010) suggested watching videos and participating in Internet activities related to *Sesame Street & Elmo’s World* in a Head Start program increased preschooler’s expressive vocabulary skills.

In addition, literacy events include shared book reading, a primarily instructional event (van Kleeck & Schuele, 1987) involving an interaction between a parent and a child around a book where children acquire skills related to later literacy success (Anderson, Hiebert, Scott, & Wilkinson, 1985). During shared book reading, children learn the page must be turned to move on to the next part of the story, print occurs in a left-to-right fashion, and print is a constant construct as anyone who reads the same book reads the same words (Paul & Norbury, 2012). Because shared storybook reading is a key piece of this study, it will be elaborated upon in the next section.

**Shared storybook reading.** Importantly, research has indicated the rate of recurrence of adult-child shared book reading while the child is between ages one to three is significantly related to teachers’ assessments of literacy learning at age five and reading comprehension performance by age seven (Wells, 1985). A caveat however, is that the act of parents reading to their children does not guarantee children will develop early literacy skills. Quality in this case is more critical than quantity; meaning how the parent reads to the child has more impact on literacy skill development than how many books the parent reads. While parents should
individualize their interaction style to their child, active involvement on the part of the child, such as answering questions about the storybook, is more beneficial than passive participation (Reese, Cox, Harte, & McAnally, 2003; Senechal, Thomas, & Monker, 1995).

Pearman and Lefever-Davis (2006) emphasize the value of the interaction occurring in shared book reading between an adult and child: “Since children learn most words in their oral language […] incidentally, reading aloud exposes them to new vocabulary words modeled by a fluent reader and nested in context” (p. 305). Furthermore, it is vital for young children to interact with adults, which include feedback as a part of literacy learning (Neuman & Roskos, 1997). Specifically, the responsiveness of caregivers in a child’s environment has a strong relationship with both language and literacy skills (Roberts, Jurgens, & Burchinal, 2005). Shared reading impacts later reading success (Snow, Burns, & Griffin, 1998). Participating in discussions surrounding the books (Heath, 1982) and purposefully making children aware of the print in books (Justice, McGinty, Guo & Moore, 2009) is also advantageous.

**Predictors of Literacy Success**

Emergent literacy skills predicting later literacy success include oral language, print awareness, and alphabet knowledge. In addition, the National Institute of Child Health and Human Development’s (2000) Report of the National Reading Panel recognized the influence of phonological awareness, phonics, vocabulary, reading fluency, and reading comprehension upon later reading and writing skills.

**Oral language.** It is well established that oral language is a strong predictor of literacy success, particularly reading comprehension. In fact, research shows oral language skills and literacy skills are “mutually enhanced by one another” (Senechal, LeFevre, Smith-Chant & Colton, 2001, p. 444) and develop reciprocally (ASHA, 2006). However, Kamhi and Catts
(2012) caution the relationship of language skills to later reading skills sometimes goes unnoticed as more emphasis is placed on alphabet knowledge and phonological awareness. Yet, language skills deserve recognition as a predictor of literacy success because at age five children are concurrently gaining information about story script and using compound sentences to express themselves, both keys for inferencing and reading comprehension.

There is a substantial body of literature demonstrating the influence of oral language and its positive relationship to literacy (Senechal et al., 2001; Kamhi & Catts 2012). Inversely, students who struggle with language skills or have diagnosed language disorders are at risk for later reading difficulties (Bishop & Adams, 1990; Catts, Fey, Zhang, & Tomblin, 2001). Oral language skills that have an impact on later reading skills include expressive language, vocabulary, syntax and story retelling (Lanter & Watson, 2008; van Kleeck, 2008). These skills are foundational to storybook understanding, delayed skills in this area will cause readers to struggle to answer questions related to a story. Further, van Kleeck (2008) suggested reading comprehension is influenced by oral language, specifically, shared storybook reading during preschool years assists in developing oral language, increasing later reading comprehension skills. Finally, children who have good reading comprehension skills have better overall language comprehension skills than their peers (Snow, Burns, & Griffin, 1998).

**Print Awareness.** Print awareness includes sensitivity to the marks in one’s written language. Both alphabet knowledge (awareness of letter names) and print concepts (knowing how print is organized) are part of print awareness (Justice & Pullen, 2008). Print concepts, then, include knowledge of both the arrangement of print and the purpose of print (Kaderavek & Justice, 2004). Examples of print concepts occurring in the preschool years are awareness of
environmental print, recognizing one’s own name and learning that strings of letters separated by a space, form words (ASHA, 2001; Kaderavek & Justice, 2004).

According to Justice and Ezell (2004), print awareness develops in the following stages: print interest, print functions, print conventions, print forms, and part-to-whole relationships of print. First, children develop an interest in print by noticing print in their environment, such as finding their name and peers’ names in the preschool classroom on tables, cubbies, and coat hooks (Levin & Ehri, 2009; Share & Gur, 1999). Next, they understand that print has meaning. Secondly, an understanding develops for the function of print—it provides details beyond the picture. Third, children learn print conventions that in alphabetic script there is a left-to-right orientation. In the fourth stage, print forms, children begin to learn the names of the letters, and the final stage, part-to-whole relationships of print, children learn that smaller units (letters) combine to form larger units (words).

**Alphabet Knowledge.** Developmentally, children at the age of three are learning letters, in fact some children know a few letters as early as the age of two, especially in high print homes and/or homes where books are read on a frequent basis (Pence-Turnbull & Justice, 2012). At age four, alphabet knowledge is related to invented spelling abilities (Niessen, Strattman, & Scudder, 2011).

Children as young as two begin to have an understanding of the alphabet by learning the alphabet song (Kamhi & Catts, 2012, vanKleec & Shuele, 1987). After learning the alphabet song, children begin to learn the alphabet shapes through activities/objects in their environment like magnetic alphabet letters on the fridge, alphabet letters on computer keyboards, (Kamhi & Catts, 2012) and letters on food labels.
The letters in a child’s name are generally the letters he learns first, known as the “own-name advantage” (Share & Gur, 1999; Tremain & Broderick, 1998). Besides the own-name advantage, several different theories exist for how children learn letter names such as letter-name pronunciation effect, letter-order hypothesis, and consonant order hypothesis (Justice, Pence, Bowles, & Wiggins, 2006). In the letter-name pronunciation effect, letters in which the name of the letter is part of the pronunciation are easier to learn (e.g. letter B is pronounced /bi/ making it easier to learn than X /ɛks/) (Justice, Pence, Bowles, & Wiggins, 2006; Foulin, 2005; Nation & Hulme, 1996). The next theory, letter-order hypothesis refers to children learning letters at the beginning of the alphabet song prior to letters at the end of the alphabet song (e.g. A, B, C are learned before X, Y, Z). Finally, the consonant-order hypothesis suggests children learn letters in a sequence parallel to the sequence in which phonemes are developed (e.g. learning B and P before L and R).

**Inside out and Outside in**

During the emergent literacy stage, children are learning to understand the meaning of print. Whitehurst and Lonigan (1998) provided a model for looking at both print awareness and story comprehension.

Whitehurst and Lonigan (1998) suggest two separate processes of emergent literacy skills exist: “inside-out” and “outside-in”. Inside-out skills are directly tied to the words involved in reading and writing, and are known as word recognition skills. Therefore, inside-out skills include the rules of sounds in the printed text (e.g. phonemes, graphemes) and the child “translate[s] a sequence of graphemes into sounds” (p. 855) to help him understand the words written in the story.
Conversely, outside-in skills are skills related to the child’s sensitivity to the context of what is being read to them and are connected to reading comprehension skills. For outside-in skills, the child brings in their world knowledge to understand the story. Both of these skills are vital for later reading success, and occur concurrently in proficient readers.

**Story schema**

Thorndyke and Yekovich, (1979) define story schema as memories for the organization of stories and their associated parts. Story schema assists with information storage and retrieval, allowing processing of a story to be hierarchical so the reader can place more emphasis and attention on important information and less emphasis on story details (Meadowcroft & Reeves, 1989). Even young children know that “Once upon a time […]” is how some stories begin, and they end with “the end”. According to Westby (2012), in order to gain information from the story as a whole, a child needs both a content schema (mental representation for the story facts) and a text schema (organization for the content information). Schema assists individuals in day-to-day life in acting appropriately in familiar situations (e.g. ordering at a fast food restaurant), making inferences as needed while reading (e.g. two of the three pigs were lazy), and “read[ing] between the lines” (e.g. A pig should not open his door to let a wolf in. That will cause problems!) (p. 167). A lack of knowledge about story schema relates to difficulties with inferencing skills, which will be discussed next.

**Inferencing**

Interacting with children during shared storybook reading includes asking both literal and inferential questions (van Kleeck, 2008). Younger children can be guided to higher level inferencing when adults use *think alouds* to help the child answer these questions, access prior knowledge thereby linking the appropriate prior knowledge to the current book. For example,
when reading *The Three Little Pigs* a teacher or caregiver might say: “I’m thinking this is where the pig is doing something very silly. His house will fall down if it is made of sticks. He should use something else.” Thinking aloud strengthens reading comprehension as it assists children in making connections to arrive at appropriate inferences (WETA Public Broadcasting, 2015).

Inferencing skills in preschoolers assist them in developing the early concept of story structure and what will later become the story sequence or structure including story grammar components (setting, problem, attempts to solve the problem, emotional response, and solution) (van Kleeck, 2008). These components form a “causal chain” (Applebee, 1978, Westby, 2012) and understanding the connections between events is important to understanding the story as a whole.

Types of inferences required for comprehension include: anaphoric reference (a pronoun that refers to a noun introduced previously in the text) and bridging/relational inference (making connections of related information, “bridging” information from earlier in the text, for example, Aubrey was putting her toys away. She could hear music.) Other inferences include explanation-based/causal inference (understanding causes and consequences of actions, for example: *Matthew put water in the pitcher. The pitcher was full.*), predictive (guessing what may occur, for example, predicting what people will do when they learn a snow storm is coming), goal inference (determining actions/plans of characters, such as in the *Little Red Hen, the Little Red Hen cuts the wheat because she wants to make bread*) and elaborative inference (understanding relationships that cannot be explained by causal relationships, but not necessary for interpretation of the text. For example, Joyce could not sleep one night. The next day the doctor gave her some *medicine for her pain.* An elaborative inference would be Joyce called the doctor right away in the morning to make an appointment (Westby, 2012).
Inferences made in story comprehension are also needed in social situations in order to understand, to interpret, and to predict the emotions of others. In social contexts, people must differentiate between what is in the real world and what happens in their minds. Making this distinction in inferencing requires a Theory of Mind (TOM), which will be described later in this dissertation (Westby, 2012).

**Essential Language and Literacy Skills**

The National Institute of Child Health and Human Development’s (2000) Report of the National Reading Panel (2000) outlined five essential early language and literacy skills related to later development of reading and writing. They listed phonological awareness, phonics, reading fluency, vocabulary, and reading comprehension. Since learning more about what contributes to reading comprehension is the objective of this dissertation, focus will be primarily on vocabulary and reading comprehension; however, the other three components will be defined within the context of comprehension. Skills in phonological awareness, phonics, and reading fluency all facilitate increased automaticity of word recognition or decoding which allows more mental attention for comprehension.

**Phonological awareness.** Phonological awareness is the purposeful ability to attend to and manipulate the sound structure of a word absent from meaning (Carson, Gillon, & Boustedt, 2013; Torgesen & Mathes, 2000; Lundberg, Larsman, & Strid, 2012). It is considered an umbrella term encompassing awareness of syllables (i.e. understanding parts of words such as *cow + boy* make *cowboy*), onset-rime (i.e. dividing a word into two parts with the first consonant or consonant blend (onset) and the second including the first vowel and all the remaining letters (rime) as in *b-ag and pl-ate*) rhyming (e.g. *hat, rat, cat*), and phonemes (e.g. */k/ + /æ/ + /t/ = *cat*) (Moats, 2000). Some children by the age of two are already developing phonological awareness
Phonological awareness is one piece of the puzzle for early literacy development as it is strongly related to later word recognition skills.

**Phonics.** While phonological awareness focuses on manipulating the sounds (phonemes) in words, phonics involves the relationship between graphemes and phonemes, and includes developing alphabetic knowledge and spelling rules (National Institute of Child Health and Human Development, 2000; Robertson, 2013). For example, that the letter *s* makes the */s/* sound is first learned along with the word *seal* and the letter “*s*” followed by other spelling combinations including *celery, circus,* and *cycle* (Moats, 2000). Long before children learn these phonics rules, they use the correct phoneme incidentally. However, when they begin to learn to spell, phonics rules are explicitly taught (e.g. silent *e* rule).

**Reading fluency.** The next essential skill, reading fluency refers to the speed and accuracy of reading text (National Reading Panel, 2000). Practice is required in order for reading accuracy to increase (Snow, Burns, & Griffin, 1998). Following this practice, when children are reading smoothly, word recognition becomes more automatic, therefore allowing more working memory capacity for comprehension (Snow, Burns, & Griffin, 1998).

**Vocabulary.** For years, researchers have recognized the relationship between vocabulary and reading comprehension, although the specific causal link has not yet been identified (Snow, Burns, & Griffin, 1998; National Reading Panel, 2000). The development of a child’s vocabulary begins with parents reading aloud to their child on a frequent basis and talking about events and activities within their daily routines (Elley, 1989; Kamhi & Catts, 2012; van Kleeck, 2008; Whitehurst & Lonigan, 1998). Furthermore, in the classroom, preschool teachers’ reading to children is related to preschoolers’ expressive vocabulary development and letter knowledge,
building a solid foundation of receptive vocabulary skills in kindergarten (Zucker, Cabell, Justice, Pentimonti, & Kaderavek, 2013). The interaction during the read aloud (i.e. the teacher reading out loud to a large group of students) is important, as teachers’ explanation of words can increase students’ vocabulary (Elley, 1989).

Vocabulary knowledge at a young age is valuable for later reading comprehension skills (van Kleeck, 2008). Robertson (2013) indicated knowing the meaning of more words allows readers to comprehend more easily and quickly. In the preschool years, some of the semantic skills children are developing include understanding and use of vocabulary to indicate size such as *big* and *small* and the use of conjunctions such as *and*, *so*, and *because* to connect sentences and guide inferencing (Chapman, 2000, Paul & Norbury, 2012, Westby, 2012). Within the preschool classroom children begin to develop an understanding of multiple meaning words (van Kleeck & Shuele, 1987) such as *trip*, *bat*, and *fly*. According to van Kleeck and Schuele, 3-year old children know that one object can have multiple meanings. Reading facilitates this vocabulary learning necessary for comprehension.

It is important to differentiate that vocabulary knowledge includes both vocabulary breadth and depth. Vocabulary breadth is the quantity of words known, while vocabulary depth is how well words are understood. Research has demonstrated vocabulary depth predicts later comprehension abilities (Ouellette, 2006; van Kleeck, 2008). Therefore, it is suggested parents ask questions targeting vocabulary while reading storybooks.

**Asking and answering questions.** Asking questions during shared reading fosters development of oral language skills that rely on inferencing, including classroom discourse (van Kleeck, 2008). Blank, Rose, and Berlin (2003) developed an assessment known as the *Preschool Language Assessment Inventory, 2nd edition*, which requires children to answer questions from
four levels of increasing complexity: matching, selective analysis, reordering, and reasoning. Different levels of abstraction indicate the distance or “how close or how far removed language is from the material being discussed” (Westby, 2007).

A description of each level and sample questions will follow. The first level of questions (Level 1) is known as matching questions since the language to answer the questions is found by looking at pictures in the book, such as “show me the flower” when the flower is closely pictured. Selective analysis (Level 2) questions require prior knowledge from experiences and ask about less obvious features of objects such as attributes (e.g. “What color is the cup?”), location (e.g. “Where is Bob?”), and functions (e.g. “Show me what mom uses to dig.”) The next level, reordering of perception (Level 3) requires looking at objects in a variety of ways, using insight and discernment about objects and experiences to answer these questions. Sample questions from reordering of perception include negative terms questions such as “Which one is not something you wear?” identifying an alternative, “Bob is surfing. What other things could you do in the water?”; and taking a role “What would you do if you were a cat?”. Finally, Level 4; reasoning about perception requires the child to use abstract thinking and predicting skills. The “why” questions are asked at this level. Questions from reasoning about perception include those that require justification of information and explaining inferences from observations. Examples include “Why does everyone want a painting?” and “Why is Bob wet and cool?” (Blank, Rose, & Berlin, 1978; 2003).

While several different ways to ask questions exist, for example, wh-questions, they are not as sensitive as Blank et. al’s (2003) method as these questions are hierarchical. Blank et al.’s questions have different levels within the same wh-word (e.g. A “what” question can have three
different levels of abstraction). Asking and answering questions are natural methods of interacting with printed stories.

Young Children’s Interest in Literacy Through Technology

Most children enjoy looking at books and being read to, which have historically been relatively passive activities. Now, in today’s society, there are more options for accessing print and opportunities for engaging with the printed story because devices with screens are easily accessible and obtainable for many children, especially with the advent of smartphones and tablets (Ernest et al., 2014). To further demonstrate the proliferation of technology, a recent survey of 350 parents in a low-income, minority community in Philadelphia found that 83% of the households owned tablets and 77% had smartphones. In addition, the parents reported that at age 4, approximately 66% of the children had their own tablet (Kabali et al., 2015).

Given this easy access to mobile technology, parents want to present print to their children in fun and interesting ways and are turning toward the use of technology as a learning tool because of its availability. Therefore, literacy may be displayed to children in a variety of screen formats besides TV. In fact, Labbo (2009) posited that computers are viewed as “unique spaces for thinking, communicating & seeking entertainment” (p. 209).

The National Association for the Education of Young Children (NAEYC) and the Fred Rogers Center (2012) suggest when used with adult guidance, technology can enhance learning; however, without such guidance, technology can be detrimental to learning. With guidance, children do need to become “technology-handlers” to develop digital literacy similarly to becoming “book handlers” as a part of emergent literacy development (National Institute for Literacy, 2008). Early childhood settings provide all children developmentally appropriate access to a variety of technological devices including but not limited to digital cameras,
interactive whiteboards, and tablets to enhance the curriculum and to expose children to
technology opportunities that may be unavailable to the children at home (NAEYC, 2012). The
NAEYC recommends technology be used in ways which encourage turn taking, decision
making, problem solving, and critical thinking while encouraging both on screen and off screen
interactions. The American Academy of Pediatrics (2016) has cautioned against the use of
screen media for children under the age of 2 years except for video chatting with family
members, and that media use should include an interactive component. However, there seems to
be a current hypothesis that some children may enjoy technology-based literacy access more than
traditional print access. Therefore, questions are being raised as to whether technology-based
methods are as effective as traditional methods for successful literacy development. One group
of children who may relate more easily to technology is children with ASD. In the next section,
a discussion of implications for literacy development for children with autism and technology
applications for literacy follows.

**Characteristics of Autism: Implications for Literacy Development**

**Oral language development.** Differences exist in language development among
typically developing children and children with ASD. According to Janzen and Zenko (2012),
there are differences in learning word meanings, using language, and social communication
skills. Children with ASD may not realize that everything has a label, items can have multiple
labels (e.g. bag/sack, pop/soda), and one word can have several meanings (e.g. trip, fly). Literal
interpretations can also be difficult (e.g. “keep your eye on the ball”).

In the use of language, children with autism may use echolalia, which is borrowed and/or
repetitive phrases and sentences (Janzen & Zenko, 2012). At times children with ASD may not
be able to formulate an appropriate response in conversations, so they borrow words from other
people, from television shows or movies, or from rules or statements often repeated in the classroom. The use of such repetitive language may also occur when children respond to questions about a storybook.

Socially, individuals with ASD have difficulty understanding the perspectives of others, making sense of nonverbal information (facial expression, body language), showing social judgment, generating responses based on fluctuating demands of situations, and maintaining relevant information when engaged in group activities to have a common experience to share. These differences in social communication skills can influence the learning of social rules and norms in that these rules are learned without flexibility. To elaborate on how these difficulties display themselves in an assessment situation, Janzen and Zenko (2012) describe a language assessment item for prepositions that required a child with autism to point to the picture that shows “behind”. The child’s response was “That’s not appropriate.” For the child, the literal interpretation occurred because of a rule “Don’t show people your behind, it’s not appropriate” (p.44). The child had learned this rule, but was unable to adapt to the testing demands due to the rigidity of his learning.

**Cognitive characteristics.** Three major cognitive characteristics of ASD limit understanding of stories for children with this diagnosis: theory of mind, executive function, and central coherence. While these three characteristics are distinct, some overlap exists among them.

**Theory of mind. (ToM)** When viewed from a wide lens, ToM is synonymous with the term social cognition (Prelock & Hutchins, 2014). Social cognition includes several skills such as perspective taking, the concept of false belief, understanding mental state terms, and empathy, among others (Prelock & Hutchins, 2014). With regard to perspective taking, ToM impacts not
only one’s ability to understand the thoughts and motivations of others and why those thoughts and motivations are different from their own, but also using this understanding to predict or explain others’ behavior (Janzen & Zenko, 2012; Carnahan & Williamson, 2010).

“In their everyday lives people with autism lack an intuitive understanding of other people” (Tager-Flusberg & Joseph, 2005, p. 310). This is true for characters in books as well as interacting with others in conversation. People with autism struggle to understand that others can have different feelings than the feelings they have (Janzen & Zenko, 2012).

Infants have the ability to interpret the perspectives and intentions of others, one of the first skills to emerge in ToM development (Tager-Flusberg & Joseph, 2005). During story reading, typically developing children demonstrate ToM. By age three, some children are able to understand a narrative from the perspective of the main character and by age five, children are able to take the perspective of any character in a story (Dodd, Ocampo, & Kennedy, 2011). For example, children understand that the Little Red Hen wants to eat the bread herself because the other characters within the story did not help her make the bread.

Another example of perspective taking involving empathy might be reading about a boy who fell down and scraped his knee at the park. In this situation, typically developing children may show empathy, relating this event to a personal experience of getting hurt at a playground. A child with autism does not understand that the boy is hurt, so he would not understand why the boy was crying nor would he understand his motivation for running to his mother.

When viewed from a narrower lens Theory of Mind (ToM) involves the attainment of false belief understanding. False belief is demonstrated by the realization that assumption and reality are two separate concepts (Wellman, Cross, & Watson, 2001). Frequently, false belief is assessed using the Sally-Anne task, a task involving a literal and perceived change in location.
Since individuals with ASD tend to have challenges in the area of ToM, difficulties can arise with reading comprehension as they struggle to relate to the feelings, motivations, and goals of the characters in a story (Carnahan & Williamson, 2010; Happe, 1994; Prelock, 2006). Difficulties with theory of mind and executive function together influence problem solving skills and processing new information, such that children with ASD struggle to construe a story character’s feelings and intentions, which are essential for story understanding and comprehending skills (Twachtman-Cullen, 2000).

Having both “wide and narrow” ToM skills is vital to story comprehension as one study found more than 75% of children’s books contained internal state language and 34% contained the concept of false belief, both of which are related to theory of mind (Cassidy et al., 1998). Without this understanding, children will have difficulty comprehending story schema. While ToM skills assist with comprehension of the story as it is read, the next skill, executive functioning, helps with story comprehension by assisting the reader in applying background knowledge to the text.

**Executive functioning.** Executive function encompasses the skills necessary for mentally sustaining a goal and behavior management for carrying out the goal, required for critical thinking and understanding the perspectives of others (Carnahan & Williamson, 2010; Happe & Frith, 2006; Kenworthy, Yerys, Anthony, & Wallace, 2008; Zenko, 2014). Other cognitive processes included in executive function are planning, working memory, inhibition, and cognitive flexibility (Yerys, Hepburn, Pennington, & Rogers 2007; Zenko, 2014).

Carnahan and Williamson (2010) explained how difficulties with executive function in children with ASD makes it difficult to connect new experiences with prior knowledge. Zenko
(2014) added, “It is hard for them to take in large chunks of information and relate the new information to similar information they already know and sift out the unimportant details” (p.148), particularly if the new information is not consistent with the “old” knowledge. Therefore, the previous knowledge can inhibit the integration of the newly learned information especially if the student with ASD is under stress (Carnahan & Williamson, 2010). They may take action without thinking about the consequences or success of prior experiences. For example, typically developing children may want to spend all of their allowance on ice cream; however, they realize they will not get another allowance until next week. Knowing that, they would probably decide not to spend all of their allowance on ice cream. However, a child with ASD may buy ice cream because they want ice cream without inhibiting their impulsivity to do so. They may not think about the consequences of that decision.

Little research exists regarding how individuals with ASD access and incorporate existing knowledge into story comprehension. Data collected in this area does imply individuals with ASD are able to access background knowledge, but have difficulty applying associated background knowledge to the current reading passage (Carnahan & Williamson, 2010).

The ability to take another’s perspective (ToM) and the ability to focus to maintain a goal, inhibit first reactions, and consider consequences are critical cognitive characteristics for the comprehension of stories. The ability to process and interpret information (central coherence) is also important.

**Central coherence.** Central coherence involves taking in and interpreting information, and it affords individuals the ability to represent events automatically. Individuals with strong central coherence take in information, make connections, and create a “big picture” or “gestalt” of the information (Ennis-Cole, 2015; Janzen & Zenko, 2012). Children with autism display
weak central coherence. They demonstrate strengths in detail-oriented processing but exhibit difficulty with global processing (Carnahan & Williamson, 2010; Ennis-Cole, 2015; Morgan, Maybery, & Durkin, 2003). Research indicates individuals with ASD have a bias or preference for this detailed-oriented processing rather than a deficiency in processing information overall. It has been shown individuals with ASD can process information on a global level when prompted to do so (Happe & Frith, 2006). Since individuals with ASD are “gestalt learners (it all goes in at once in chunks), but they are not gestalt thinkers” (Janzen & Zenko, 2012, p. 20). That is, they may take in large portions of information, but struggle to sort the pieces of information into smaller categories for storage and retrieval (Janzen & Zenko, 2012; Zenko, 2014).

Detail-oriented processing impacts reading comprehension as children with ASD may miss the texts’ “big picture” message by focusing on the details. Extreme focus on specific details or processing only those details, allows for understanding the meaning of individual words, but limits the ability to make connections beyond sentences and paragraphs required for inferencing and ultimately for story comprehension (Happe & Frith, 2006). Therefore, integrating information from entire stories or multiple sources is difficult (Carnahan & Williamson, 2010; Lucas & Norbury, 2014).

Given the literacy challenges children with ASD face related to the three cognitive characteristics of the disorder (lack of theory of mind, difficulty with executive function, and weak central coherence), individualized literacy instruction and supports are necessary. Without these individualized supports, young children with ASD may develop into adults lacking literacy skills necessary for daily living. There is lack of information regarding these three cognitive characteristics in assessment of story comprehension.
Although these three cognitive characteristics are recognized as weaknesses in children with autism, there are also known strengths, which can be capitalized upon to provide appropriate intervention. Among these are visual strengths, positive response to a predictable, structured environment; (Hume & Reynolds, 2010; Law, 2015) and an interest in technology.

**Strengths of children with ASD**

**Visual strengths.** Children with autism display a relative strength in processing visual stimuli and using visual information in advantageous ways (ASHA, 2006; Janzen & Zenko 2012; Lanter et al., 2012, Lanter & Watson, 2008). When information is clearly organized in a visual format “to highlight the critical elements, sequences, and relationships, most of those with ASD can learn to use it meaningfully” (Janzen & Zenko, 2012 p. 26). Furthermore, according to parent report, children with ASD tend to be greatly motivated by a variety of literacy materials (Lanter, et al., 2012), potentially because of their visual features. Some researchers have found that books presented via electronic screen media increase comprehension skills as visual and verbal information is processed concurrently (Kamil, Intrator, & Kim, 2000). Additionally, research has indicated the visual aspects of technology align with the visual processing assets in ASD (Shane & Albert, 2008).

**Structured teaching.** According to Hume and Reynolds (2010), the structured teaching approach developed through TEACCH (Treatment and Education of Autistic and Related Communication-Handicapped Children) is used with children with autism to organize the environment, provide visual support to maximize success and to minimize distractions within the classroom. Structured teaching involves four elements: physical structure (the organization and arrangement of furniture within the classroom), visual daily picture schedules (pictures displaying classroom activities), work systems (a system set up to indicate what and how much
work the student will do, when he/she is finished, and what he/she will do next), and visually structured activities (tasks visually designed to help a child see and understand what is expected within an activity). Daily schedules let the child know the number and order of daily tasks while work systems help the child see and understand what they will be required to do in particular locations (Hume & Reynolds, 2010). Work systems are effective for children with ASD as they increase independence of task completion and facilitate attending behavior (Hume & Odom, 2007). Often, work systems are displayed in a left to right fashion as this reinforces the direction in which we read (Hume & Reynolds, 2010).

**Interest in technology.** Both motivation and fascination with electronic screen technology have been cited clinically as influencing factors for selecting the iPad® as a treatment tool (Caron & Shane, 2014; Goodwin, 2008; Shane & Albert, 2008). This attraction has allowed some children with ASD to readily interact with the iPad® and other iOS devices without (or with very little) instruction in its operating features (Caron & Shane, 2014).

In addition to the visual feature advantages of using technology with students with ASD, technology provides other benefits as well. Computers provide a clearly defined task and reduce distractions from non-essential stimuli (Moore & Calvert, 2000; Murray 1997, 2012). Furthermore, computers do not include social components that are confusing for children with ASD, and they include predictable information and repeatable responses (Knight, et al., 2013; Murray 1997, 2012). For example, predicting what will occur in a computer program may be easier for children with autism than predicting what someone will do or say in a conversational interaction.

Additionally, when investigating the role of touch in literacy activities using iPads® for students with unspecified disabilities in the classroom, Flewitt, Kucirkova, and Messer (2014)
found through teacher interviews that the need for language to demonstrate understanding of concepts was eliminated. A response through touching the screen was adequate. The iPad® also provided “sensory access to literacy” (p. 111).

**Evidence of the Advantages to Literacy Learning Using Computers**

Past research has targeted the use and advantages of computers for literacy learning in children with ASD. Researchers in the U.K. discovered eight, 3- to 5-year-old children with ASD without experience with a computer spent more time on task with an animated computer book containing scanned pictures from a traditional book (about 10 minutes) compared to the traditional picture book with “bells and horns” (almost 3 minutes) (Williams, Wright, Callaghan, & Coughlan, 2002, p. 77). The computer book also used sounds for the characters’ voices when the character was clicked with the computer mouse. Furthermore, the computer read the story and highlighted the words when the “sound button was activated” (p. 77). All participants received both computer and traditional reading conditions. In addition, another component of the study was evaluating the word learning of the children with flashcard games in both traditional and computer format. The games on the computer were considered interactive, and “positive cheering sounds” were used as feedback for the children.

Participants were assessed at four points in this study: at baseline (prior to exposure to testing conditions), during experimental conditions, at crossover (when participants switched conditions), and after the experiment was completed. Results showed children verbalized two times the number of words within the experimental testing time in the computer condition compared to the book condition. In addition, participants’ reading scores and on-task behaviors were higher for those participants who received the computer condition first. During the last session of the reading task, five of eight children consistently identified at least three words out
of 30 targeted words from the word games. Moreover, children exhibited less opposition to engagement with the computer compared to the picture book, and parents noticed an increase in oral language during post-test recording at home (Williams, et al., 2002).

Moore and Calvert (2000) compared a teacher-led, behavioral program to a computer-assisted program for vocabulary learning for children ages three to six diagnosed with ASD. Pre-testing in this study involved children naming eighteen nouns on flashcards. Treatment in the behavior condition included naming objects through drill work by pointing or following a verbal command to give the researcher the object. Rewards for correct responses included verbal praise or an average of approximately seven and a half seconds of play with the object. The researcher gave prompts for incorrect answers until the child had a correct response. Sensory reinforcement was the primary difference in procedure between the computer condition and the behavioral condition, with sensory reinforcement occurring in one of the following ways: change in colors on the screen, animation, music, or sounds. In both treatment conditions, children were taught six nouns, and a post-test using flashcards of those six nouns was completed one week following treatment. Findings indicated children learned 74% of targeted nouns in the computer condition and 41% in the teacher condition.

The effect of a computer program, Alpha, on the early reading and communication skills of eleven children with autism was investigated by a group of researchers in Sweden (Heimann, Nelson, Tjus, & Gillberg, 1995). Participants had a mean chronological age of 9:4 with a receptive language age between 2:9 and 7:0 and a mental age between 3:0 and 9:5. Children were diagnosed at a neuropsychiatric clinic or at a hospital and their diagnosis was verified by the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988).
Alpha progresses through four different tasks: individual words, creating sentences, testing words, and testing sentences. The program begins with individual words, and once the child masters that task, he moves into creating sentences. This mode will produce an animation for the sentence the child creates. Data collected from the two testing tasks of the program showed children with autism made gains in vocabulary, phonological awareness, and word reading. However, the children did not display advances in a follow-up session.

van den Broek, Kendeou, and White (2009) postulate the use of e-books can enhance comprehension if professionals intentionally connect the e-books to prior knowledge and use them to encourage enhancement of early reading skills. These investigators stress that the use of e-books may decrease the demands on decoding and free cognitive resources to improve comprehension. However, professionals must avoid e-books that contain animations unrelated to the storyline as “It is the strategic use of the various media in such a way that the comprehending child engages in relevant processes in which he or she otherwise would not engage” (p. 69). In addition, Bus, Takacs, and Kegel, (2015) suggest that when presented with e-books including many unrelated animations or games, children participate in multitasking, which could lead to “cognitive overload” (p.82). When children multitask, they attempt to remember information about the story while attending to a semantically unrelated interactive activity, and eventually reach a ceiling for input of further information. Therefore, it is suggested when using multimedia books with additional features available, to ensure the book includes sounds, images, and animations that are semantically related to the storyline (Bus, Takacs, & Kegel, 2015; Moody, Justice, & Cabell, 2010).
**Empirical Studies Utilizing Technology Format for Children with ASD**

“There is a critical need for research on technologies […] e.g., iPad®s, iPod®s […] for academic skills” (Knight et al., 2013, p. 2645). In a literature review of technology-based interventions for individuals with ASD, the authors found the majority of studies were conducted using computers rather than tablet devices. “The dearth of quality studies makes the opportunities for research almost unlimited” (p. 2645). Furthermore, technology use for children with ASD is a relatively “young science” (Ennis-Cole, 2015, p. 26) with much yet to be explored.

For example, Alt and Moreno (2012) used the Receptive One Word Vocabulary Test (ROWVT) and the Expressive One Word Vocabulary Test (EOWVT) to examine differences between test presentation using traditional paper test plates and scanned test plates on a computer. Participants included 18 typically developing children and 18 children with ASD ages five to thirteen. No difference was found between the two test formats for either participant group. Therefore, these researchers found no advantage or disadvantage to using a static traditional paper assessment or scanned traditional assessment displayed on the computer. However, the authors caution their participants included mostly higher functioning individuals, potentially impacting their results. Additionally, participants were included in the study based on parent report of ASD rather than use of a gold standard diagnostic tool. With the changes in technology, including the introduction of tablet-based assessments such as Q-interactive® (NCS Pearson, 2015a), researchers need to explore to these newer technologies to determine their effectiveness with a variety of children, especially those who need a predictable, structured test environment.
A study in Taiwan (Lin, Chang, Liou, & Tsai, 2013) included children who were typically developing and children diagnosed with ASD (as verified by pediatric psychiatrists) assessed early literacy skills including decoding, homographs, visual and auditory vocabulary comprehension, and visual and auditory sentence comprehension via a computer with an internet-based assessment tool. Of the 300 participants, 35 were diagnosed with autism and all participants were ages four to six. The researchers noted participants received visual reinforcement for correct answers through a picture of an apple displayed in the top right corner of the screen. Each time a child earned three apples, an animation occurred. Results indicated participants with ASD scored higher than typically developing children on decoding, homographs, and the visual vocabulary subtests, but scored significantly lower on the auditory sentence comprehension subtest. Lin et al., (2013), suggested future research should use mobile technology for assessment, as some difficulty occurred with the Internet access feature from other locations. Using mobile technology testing formats without the need for Internet access would allow testing to occur in the child’s natural environment, potentially reducing anxiety, which may otherwise occur due to an unfamiliar testing environment or change in routine.

Q-interactive® provides availability of several of Pearson Publishing Company’s assessments in tablet format. While research from the publisher includes both equivalency studies of the Clinical Evaluation of Language Fundamentals, 5th edition, (CELF-5) on paper and Q-interactive® format with typically developing participants and engagement of individuals with autism using the Q-interactive® format of the Weschler Intelligence Scale for Children, 5th edition, (WISC-V), an equivalency study for the PPVT-4 is not available. It should also be noted that research conducted by individuals not affiliated with Pearson, using tests presented on the iPad® via Q-interactive® has investigated the administration of the Goldman Fristoe Test of
Articulation, 3rd edition, (GFTA-3) a test for articulation (Buhr, et al. 2016), and scoring time when given to mostly typically developing children.

Evidence for Preschool Children with Autism and Tablet-Based Storybooks/Reading Comprehension

Most of the available research regarding literacy for children with ASD has been conducted with older children who were in the conventional literacy stage. Less research has been conducted with children with ASD who were in the emergent literacy stage (Fleury, Miramontex, Hudson, & Schwartz, 2014; Lanter et al., 2012). This information is vital for early childhood specialists, as it is well-documented literacy experiences in preschool contribute to later reading skills (Dunst et al., 2006).

When investigating reading comprehension in older children with a diagnosis of ASD, Price (2011) found middle school, high school, and 18-22 year-old students who were receiving special education transition services answered comprehension questions with greater accuracy using an e-book on the iPad® than reading from a traditional paper story. Participants in this study were at minimum four grade levels behind in reading. Overall, comprehension accuracy increased by 21% for middle school students and 25% for high school students using the iPad® compared to traditional paper stories. Teachers administering the comprehension questions completed a questionnaire at the conclusion of the study and reported students participated in fewer off-task behaviors. Less is known about younger children's abilities to answer questions about storybooks using electronic screen media. Additionally, research connecting the relationship between reading comprehension and e-books including those on tablets is limited (Schugar, Smith, & Schugar, 2013).
Given the dearth in the literature about the iPad® and its use with children with ASD for both assessments and story comprehension, the current study focused on questions to address these research needs.

**Research Questions**

1) Do children with autism score differently on receptive vocabulary when the PPVT is presented via an iPad® compared to paper format?

2) Does a difference exist in receptive vocabulary scores of children with ASD and vocabulary-age-matched peers on the PPVT when administered via the iPad®?

3) Are there differences in story comprehension scores between children of different classification (vocabulary age-matched peers versus children with ASD)?

4) Is there a difference in comprehension scores when children in both groups are read to with a different modality (iPad® book with the *read-to-me* feature activated, iPad® book read by the PI, and traditional, paper book)?

5) Is there a difference in how children with different classifications (vocabulary matched peers and children with ASD) respond to comprehension questions with varying modalities of storybooks (iPad® book with the *read-to-me* feature activated, iPad® book read by the PI, and traditional, paper book)?
CHAPTER III

Method

This study used an experimental equivalent-groups design to examine differences between vocabulary and story comprehension scores using paper and iPad® presentation of questions. First, differences were determined between paper-based and tablet-based receptive vocabulary test administration. Second, storybook modalities including traditional storybook reading by an adult, iPad® storybook reading by an adult, and a read-to-me feature on an iPad® were compared. Participants included children diagnosed with autism and their vocabulary-age-matched peers. Instrumentation and procedures for determining eligibility, study protocols, and analysis of results are discussed in this chapter.

Participants

Participants with ASD. The Wichita State University Speech-Language Clinic and local school districts in the Wichita metropolitan area served as recruitment sites. A total of eighteen children with a diagnosis of ASD were considered for this study. To be involved in the study, participants met eligibility requirements, which included medical diagnosis of autism, vision and hearing within normal limits, English-speaking (not learning English as a second language), communicating verbally without the use of an augmentative alternative communication (AAC) device, ability to independently attend to stimuli on a tablet device and traditional storybook, and receptive vocabulary score ± 1.5 SD from the mean. For children recruited from local school districts, the parent confirmed the children had passed both vision and hearing screenings, and for children recruited from the WSU Speech-Language-Hearing Clinic, confirmation of hearing screenings was verified with their records and confirmation of passed vision screening was
provided by parent report. Participants were not included in the study if eligibility requirements were not met.

Five children did not qualify for the following reasons: English was not the first language, did not pass the language screening, did not score within 1.5 standard deviations of the mean, did not return for day 2 testing, and could not attend to a paper book following multiple attempts. Thirteen qualified and completed testing. Their chronological ages ranged from 4 to 6 years. Parents/guardians of the participants signed an informed consent document approved by the Institutional Review Board (IRB) at Wichita State University giving permission for their child to participate in the research study (see Appendix E).

**Participants with typical development (TD).** Thirteen TD participants ranging in age from 3 to 6 years from the Wichita area were recruited. TD children were matched to the ASD participants for gender and receptive vocabulary age (+/- 6 months). Participants with TD were included if they had normal vision and hearing and their primary language was English as reported by the parents. Individuals diagnosed with a developmental disability or speech-language disorder were not included in this group. Vocabulary age equivalents for the typically developing participants ranged from 3-years, 8-months to 8-years, 1-month.

**Instruments for eligibility for all participants**

**Preliminary phone interview.** Parents of potential participants completed a preliminary phone interview with the PI to determine their child’s eligibility for the study. All parents answered the following: 1) “Tell me about what your story time routine with your child looks like,” 2) a) “Does he have any experience using an iPad®? b) How long has he used an iPad®?” 3) “Does your child read any iPad® stories?” 4) a) “Has your child read any books in the Pete the Cat book series?”, b) “How many?” and 5) “Has your child passed vision and hearing
screenings?”. Parents of children with autism were asked questions regarding the child’s diagnosis and current treatment, including the following: 1) a) Describe how your child communicates. b) Does he communicate verbally? 2) What classroom supports (e.g. daily picture schedule)/services (e.g. speech therapy, occupational therapy) does your child receive? 3) What is the frequency/duration of these services? 4) How did your child receive his diagnosis? If children did not communicate verbally, attend to a story, or did not pass vision or hearing screenings, they were eliminated from the study at this point. After asking the parents questions, the PI shared the time commitments and format of the testing sessions.

**Eligibility testing.** All participants engaged in a screening administered by the PI to determine whether they qualified for the study using the PPVT paper-based test and a 10-minute language comprehension screener modified from the Preschool Language Assessment Inventory (PLAI-2, Blank, Rose, & Berlin, 2003) to assess whether or not the participant could answer Level 1 and 2 questions (see Appendix C).

**Language screening.** The language comprehension screening consisted of 10 questions with picture stimuli items (see Appendix C). The questions followed the first and second levels of abstraction from the Preschool Language Assessment Instrument, Second Edition (PLAI-2, Blank, Rose, & Berlin, 2003). *Level 1 of Abstraction* is the most concrete or least amount of abstraction. An example of a *Level 1* question is: “What is this?” while an example of a *Level 2* question is: “Where is the duck swimming?” Another certified speech-language pathologist provided reliability checks for question level assignment (*Level 1* or *Level 2*). Participants were asked 10 questions: five *Level 1* questions and five *Level 2* questions per story. Questions were presented during book reading in a manner (using similar question forms) and sequence similar
to what occurs in the PLAI-2 (Blank, Rose, & Berlin, 2003) (See also the section “Asking and Answering Questions” in Chapter 2).

Although the PLAI-2 (Blank, Rose, & Berlin, 2003) has four levels of abstraction (least to most abstract) the screener only included Level 1 and 2 questions. To qualify for participation in the study, children needed to achieve the criterion score of 80% (four out of five) correct as an acceptable rating on Level 1 questions and 60% (three out of five) correct as an acceptable rating on Level 2 questions. Following the screening, if children met the criterion scores, testing commenced.

**Receptive vocabulary testing.** The PPVT-4 (Dunn & Dunn, 2007) was administered to all participants according to the procedures listed in the manual to assess receptive semantic language skills and to match participants with ASD to participants who are typically developing. CSD (Communication Sciences and Disorders) graduate students trained by the PI administered the paper-based PPVT-4 to typically developing participants. The PI supervised the students and verified standard and age-equivalency scores. Only the PI tested participants with ASD. Participants pointed to one picture from an array of four, thus indicating their response to the vocabulary word spoken by the examiner. Research has shown that vocabulary skills are related to “general verbal ability” (Dunn & Dunn, 2007, p.1). Additionally, vocabulary development may be considered a gauge for a child’s cognitive and social development. For preschoolers, vocabulary skills can be an indication of school readiness (Dunn & Dunn, 2007).

**Reliability.** Internal consistency reliability of the PPVT-4 includes split-half reliability, which averaged .94 or .95 on Form A and Form B and alpha coefficient was .97 for Form A and .96 for Form B. The test authors caution that the alpha coefficient may be overestimated as
scores were filled in for items not administered. Alternate-form reliability coefficients on the PPVT-4 are between .87 and .93. The test-retest correlation is .93.

Validity. The PPVT-4 has been correlated with other assessments including the Expressive Vocabulary Test, Second Edition (EVT-2; Williams, 2007) and the Clinical Evaluation of Language Fundamentals (CELF-4; Semel, Wiig, and Secord, 2003).

The correlation between the PPVT-4 and EVT-2 for ages two to four is .81 and for ages five to six it was .84. The PPVT-3 was correlated with the PPVT-4 with a correlation coefficient of .79 for ages two to four and .82 for ages five to six. Additionally, the PPVT-4 was correlated with the CELF-4 subtests at ages five through eight: Core Language .73, Receptive Language .67, and Expressive Language .72 (Dunn & Dunn, 2007).

To achieve content validity, the PPVT-4 target words were chosen from words that were easily represented by colored pictures, and the words were selected from a variety of topics. Furthermore, the words were taken from a “pool [which] consisted primarily of entries in the Merriam-Webster’s Collegiate Dictionary (2003) and various editions of Webster’s New Collegiate Dictionary (1953, 1967, 1981)” (Dunn & Dunn, 2007, p. 58).

Verification of diagnosis of participants with ASD

Medical diagnosis of autism was reported by parents, teachers, and/or other educational professionals, confirmed through school record and/or medical record, and verified by the researcher with the use of the Childhood Autism Rating Scale, Standard Version, 2nd edition (CARS-2-ST; Schopler, Van Bourgondien, Wellman, & Love, 2010b) for children younger than 6 and the Childhood Autism Rating Scale, High Functioning Version, 2nd edition (CARS-2-HF; Schopler, Van Bourgondien, Wellman, & Love, 2010a) for children 6 years of age. The CARS-2-ST shows behavioral features of ASD, correlating with the symptoms of ASD as defined by
the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; American Psychiatric Association, 2013). Graduate students trained and supervised by the PI completed a parent interview related to the 15 behavioral observation items on the CARS-2-ST. The PI conducted the behavioral observation of the participants with ASD during the testing sessions. Scoring of the CARS-2-ST utilized information from both the interview and observation.

Schopler, Van Bourgondien, Wellman, and Love (2010b) developed this assessment to include 15 behavioral observation items: relating to people (how the child behaves during social interactions with others); imitation (copying verbal and nonverbal behaviors); emotional response (reaction to both positive and negative situations and whether the feelings are fitting for the situation); body use (appropriateness of movements and eccentricities such as rocking, spinning, hand-flapping, or toe-walking); object use (interest and use of toys); adaptation to change (difficulties in deviating from routines and transitioning from one activity to the next); visual response (looks at visual attention behaviors such as looking out of the corner of the eyes, eye contact); listening response (inclination toward or fear of certain sounds, (e.g. vacuum, fireworks), hypersensitivity to certain sounds); taste, smell, and touch response and use (refraining from eating certain foods, low tolerance to certain textures or smells or overly interested in certain foods, textures, smells); fear or nervousness (fear of a specific item (e.g. action figure) or lack of fear when fear should exist (e.g. not concerned about running into a street)); verbal communication (use of language, including the use of jargon); nonverbal communication (use of body language, facial expressions, gestures); activity level (movement in structured and unstructured environments including under- or over-activity); level and consistency of intellectual response (whether variation exists in cognitive skills such as savant or peak skills in art or math); and general impression (overall qualitative rating of no ASD, mild
ASD, moderate ASD or severe ASD). Each of the 15 behavioral observation items is rated on a scale from 1-4 (1 = within normal limits, 1.5 = very mildly abnormal, 2 = mildly abnormal, 2.5 = mildly-to-moderately abnormal, 3 = moderately abnormal, 3.5 moderately-to-severely abnormal and 4 = severely abnormal) (Schopler et al., 2010b). The considerations for rating on the scale vary according to each item. For example, in the relating to people item, professionals rate a 1 for no difficulty with relating to people (some shyness or aggravation when instructed what to do, but not atypical), while a rating of 4 is given for “severely abnormal relationships” in which the child does not begin interactions with an adult, and much effort is required to gain the child’s attention (CARS 2-ST Protocol; Schopler, Reichler, & Renner, 2010). In the current study, item 14 was not rated, as there was no measure of intelligence included. Information received from the CARS-2-ST provided information and assisted the PI in preparation for further testing and development of environmental structure in the current study (See Appendix K for CARS-2-ST results). For example, the PI made adjustments to the visual schedule for one participant as he could only handle two activities represented visually at one time; therefore, he was presented with a “first-then” schedule. Other adjustments included keeping only the materials out necessary for the present activity, with everything for future activities hidden from sight, and adjusting breaks to take place inside or outside of the room. Additionally, information from the CARS-2-ST or CARS-2-HF was used to confirm the diagnosis.

**Instruments for study procedures**

**Book selection.** The *Pete the Cat: I Can Read* collection is a popular children’s storybook series designed for shared storybook reading with emergent readers (Dean, 2014). The main character, a cat named Pete, experiences events highly relatable to preschool-aged children. Featuring Pete as an animal rather than a child eliminates influences of gender, culture, and
ethnicity (Lee, 2013). Additionally, Lee (2013) used *Pete the Cat* books in a study with individuals with autism and found the basic language and word repetition within these books was beneficial for individuals with this diagnosis.

**Pilot study.** A pilot study was conducted with a group of typically developing children (not participants in the dissertation study) to determine the validity of the questions and whether the questions elicited an appropriate range of responses. Answers to the potential dissertation study questions were analyzed using paper versions of the three *Pete the Cat* books: *Pete the Cat: Pete at the Beach* (Dean, 2013), *Pete the Cat: Too Cool for School* (Dean 2014b), and *Pete the Cat and the Bad Banana* (Dean, 2014a). A scoring rubric was developed from these responses (See Appendix N for more information).

**Procedures to facilitate participant motivation**

**Work system.** All participants in both groups used a work system on both days of the current study (Hume, Loftin, & Lantz, 2009) containing colored photographs to indicate the sequence of activities during the testing sessions. The work system assisted participants in understanding what tasks to be completed, how many tasks to be completed, and when the participants were finished (Hume & Reynolds, 2010). For the current study, the work system was structured with plastic totes set up along the treatment room wall in a left-to-right fashion with a visual strip (Appendix I) indicating the sequence of tasks to complete and a container for the participant to place items/activities once they were completed. The rationale for utilizing a work system in the current study was to help children know what work they had to do, how much work, what would happen next, and to recognize when they were finished. This helped reduce stress and anxiety for children with ASD (Prelock, 2006). The same work system was used with vocabulary-age-matched participants to provide consistency across participant groups.
**Breaks.** Participants had two five-minute breaks during each testing session to allow them to move and engage in free play apart from the PI-directed activities. A variety of activities was provided for participants to select from including activities both inside and outside the testing room. Break activities occurring in the testing room included puzzles, a pretend pizza toy, and cling-on sticker scenes (e.g. farm, construction site, train station, beach, etc.). Activities for breaks outside of the testing room included the following: bubbles, riding a scooter, bouncing on an exercise ball, shooting baskets, or going for a walk.

**Incentive.** All participants received a snack incentive at the conclusion of each testing session. They selected their snack from an array of photographs at the end of their work system sequence. During the phone interview, the PI asked the parents about allergies and diet restrictions to ensure participants were provided appropriate snacks. Furthermore, participants’ families from both groups received a $10 gift card to the retailer of their choosing (e.g. Target, Kohl’s, Sonic, Cold Stone Creamery, Dillon’s) for the first testing session and a $10 gift card upon completion of the research testing.

**Testing schedule and environment**

All testing was completed at the university’s speech-language clinic. The participant was seated in a child-sized chair at a table with the examiner to his/her left for the book reading procedure and to the right at the edge of the table as indicated in the PPVT manual for the PPVT testing (testing procedures described later in this document). Testing sessions were video-recorded using a Sony Handycam™ HDR-CX405 HD flash memory camcorder.

**Day 1 testing procedures**

**Language screener.** Day one testing began with the language screening as
discussed above in the instruments for eligibility section. If participants did not meet the criterion scores, they were eliminated from the study following the language screening.

**Paper-based receptive vocabulary test administration.** CSD graduate students trained by the PI administered the paper-based PPVT-4 to typically developing participants. The PI supervised the students and verified standard and age-equivalency scores. Only the PI tested participants with ASD. Testing was completed following the standardized protocol per the PPVT-4 manual, Form A. These results were used to match ASD and typically developing participants on vocabulary age.

**Book reading.** During a shared reading activity, the PI presented the Pete the Cat stories in one of three formats. The book Pete the Cat and the Bad Banana was read by the PI in the traditional, paper book format, Pete the Cat: Too Cool for School was displayed on an iPad® with the PI reading the story, and Pete the Cat: Pete at the Beach was shown on the iPad® with the read-to-me feature turned on. The order in which the books were presented was randomized to control for any order effect. An example of book order is if the participant engaged in the traditional story, Pete the Cat and the Bad Banana on day one, then the other two stories Pete the Cat: Pete at the Beach and Pete the Cat: Too Cool for School were read during the testing session on day two. Participants answered a set of level 1 & 2 questions of language abstraction (Blank, et al., 2003) related to each book format (see Appendices G, H, I). Responses were video recorded.

The next section provides a description of procedures for each of the three book formats.

**Traditional.** For the traditional book, the PI began by reading the title and author aloud, comparable to the read-to-me feature in the iPad® condition, followed by text on page one. The PI paused throughout the book to ask questions. In advance, the PI wrote the 10 questions on
sticky notes affixed to the page on which the question was asked. Writing the questions in advance and embedding them in the story increased reliability (van Kleeck, 2008; van Kleeck, Vander Woude, & Hammett, 2006). During reading, the PI noted the participant’s response. After the question was asked and the response recorded, the participant turned the page and the procedure was repeated throughout the book. If the participant did not turn the page, the PI said “Let’s see what happens next”. After this prompt, if the participant still did not turn the page, the PI turned the page and continued reading. Responses were rated and coded following viewing of the video recording. Responses were scored as fully adequate (FA), acceptable (AC), ambiguous (AM), or inadequate (IA) (Blank et al., 2003). Guidelines for these ratings can be found in Appendix D. Finally, two graduate students also rated the children’s responses and intraclass correlation reliability was calculated, and the results of those ratings are described next. Model 3 intraclass correlations were run to determine inter-rater reliability among the three raters. This type of intraclass correlation (ICC) was chosen because each participant was assessed by all three raters. In addition, the raters were raters of interest rather than randomly selected. The ICC found a high degree of reliability between the three raters when rating comprehension scores for the children with autism, and the average measure ICC was .95 with a 95% confidence interval from .83 to .98 (\(F(38,76) = 31.72, p = 0.00\)). A high degree of reliability was also found from the ICC when rating comprehension scores for the vocabulary age-matched peers. The average measure ICC was .96 with a 95% confidence interval from .86 to .98 (\(F(38, 76) = 46.91, p = 0.00\)).

**Tablet 1 book reading.** In the first tablet condition, the read-aloud feature was turned off and the PI read the story, while in the second condition, the read-aloud setting was turned on. The “turn my pages” feature was turned off for both conditions. Turning off this feature requires
the digital page to be “swiped” in order for the next double page to appear and reading to continue. During the first tablet condition, procedures mirrored that of the traditional book reading. If the child swiped the book to the next page before the PI read the question, the PI went back to the previous page so all questions were asked in sequence.

**Tablet 2 book reading.** In the second tablet condition, after the tablet’s read aloud introduction to the book, the first two pages are read, then the narration stopped. The PI asked the first question from the list of 10 in the same order as the traditional story presentation. After the participant answered the question, he/she “swiped” the page. Narration continued. Throughout the tablet read aloud, the PI asked the questions on the designated digital book pages and marked the participant’s response. This procedure was repeated throughout the book. Again, if the child swiped the book to the next page before the PI read the question, the PI went back to the previous page so all questions were asked in sequence.

**Day 2 Testing Procedure**

**Book Reading.** On the second day of testing the participants were involved in shared storybook reading using the other two books not read on the first day of testing. Procedures on the second day began with book reading and answering questions, followed by tablet-based receptive vocabulary testing, and ending with reading the last book and answering questions.

**Tablet-based receptive vocabulary test administration.** Q-interactive, which displays a digital version of the PPVT-4 on Apple iPad®’s was administered via iPad® utilizing form B. With Q-interactive®, each of the two iPad®’s served a different purpose—one for the participant to respond and one for the administrator to score. The tablets were connected via Bluetooth technology, allowing for simultaneous scoring and test administration. Test information was encrypted and stored on a secure server owned by Q-interactive’s® publisher. (NCS Pearson,
These results were used for a comparison of participants’ performance on the paper-based receptive vocabulary test.

**Reliability and validity.** NCS Pearson (2015b) conducts equivalency studies on all tests prior to their release via the Q-interactive® platform. The publisher will not release a test unless score differences between traditional formats and tablet-based formats have effect sizes of 0.2 or less (NCS Pearson, 2015b). It should be noted, an equivalency study is not available online for the PPVT-4, rather, the company utilized information from the equivalency study for the -5. This is because the CELF-5 requires the examiner and participant to interact similarly to the PPVT-4 (J. Henke, personal communication, 8-25-15). Permission to utilize Q-interactive® for this study was obtained from Pearson.

**Language Screening.** On Day 2 a second component of the language screening was presented with two Level 3 and two 4 questions (one receptive and one expressive) to determine a ceiling. An example of a Level 3 question is: “These grapes are purple. What other color can grapes be?” Level 4 question: Why do people need to eat food? It should be noted that Level 3 and 4 questions may require an understanding of internal state language and understanding the others’ intentions. None of the children with ASD were able to answer all of the Level 3 and 4 questions accurately, which indicated Levels 1 and 2 were most appropriate for the current study.

**Analyses**

The PI performed all statistical analyses using IBM SPSS Statistics Version 24 predictive analysis software.

Research Questions:

1) Do children with autism score higher on receptive vocabulary when the PPVT is presented via an iPad® or paper format?
Hypothesis: The researcher hypothesizes PPVT iPad® scores will be higher.

Statistical Analysis: A paired sample t-test will be conducted to determine differences between iPad®s and paper-based PPVT test presentations.

2) Does a difference exist in receptive vocabulary scores of children with ASD and vocabulary-age-matched peers on the PPVT when administered via the iPad®?

Hypothesis: The researcher hypothesizes the children with ASD would perform the same or better than vocabulary-age-matched children’s scores on iPad® PPVT.

Statistical Analysis: A one-way repeated measures analysis of variance (ANOVA) will be conducted to determine differences between iPad® PPVT scores of children with ASD and vocabulary-age-matched peers.

3) Are there differences in comprehension scores between children of different classification (vocabulary age-matched peers versus ASD)?

Hypothesis: The researcher hypothesized there will be a difference.

Statistical Analysis: A two-way, 2 (classification: vocabulary-aged matched peers and ASD) by 3 (comprehension scores for each modality: iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book) repeated measures multivariate analysis of variance (MANOVA) was conducted.

4) Is there a difference in comprehension scores when children in both groups are read to with a different modality (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book)? Hypothesis: The researcher hypothesized that children would perform best with the iPad® book with the read-to-me feature activated.

Statistical Analysis: A 2x3 MANOVA was conducted with follow-up post-hoc paired t-test with Bonferroni correction.
5) Does an interaction exist between modality of book reading and child classification? (Is there a difference in how children with different classifications responded to comprehension questions with varying modalities of storybooks (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book))?  

Hypothesis: The researcher hypothesized that an interaction would exist.

Statistical Analysis: A 2x3 MANOVA was conducted.
CHAPTER IV

Results

The purpose of this study was to investigate potential differences between paper and tablet device presentation of assessment protocols by answering the following: (a) do children with autism score higher on receptive vocabulary when the test was presented via an iPad® tablet rather than in paper format; (b) does a difference exists in receptive vocabulary scores when the test was administered via tablet between children with autism and vocabulary age-matched peers; (c) are there differences in comprehension scores between children of different classification (vocabulary-age matched versus children with ASD) (d) is there a difference in comprehension scores when children in both groups are read to with a different modality (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book) (e) is there a difference in how children with different classifications responded to the varying modalities? does an interaction exist between modality of book reading and child classification)? (See Appendix L for raw data).

1) Do children with autism score higher on receptive vocabulary when the PPVT is presented via an iPad® or paper format?

Hypothesis: The researcher hypothesized PPVT iPad® scores would be better.

Statistical Analysis: A paired samples t-test was conducted to determine differences between iPad®'s and paper-based PPVT test presentations. Descriptive statistics are shown in Table 4.1.
Table 4.1

Descriptive Statistics of PPVT Scores of Children with Autism

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPad</td>
<td>100.46</td>
<td>16.61</td>
</tr>
<tr>
<td>Paper</td>
<td>101.07</td>
<td>14.55</td>
</tr>
</tbody>
</table>

Note: \( n = 13 \)

A paired samples t-test indicated that differences between scores of children with autism on the iPad® PPVT and the traditional, paper PPVT were not significant, \( t(12) = .32, p = .76, \) n.s. The effect size was small, \( d = (.01) \). Therefore, the hypothesis was not supported.

2) Does a difference exist in receptive vocabulary scores of children with ASD and vocabulary-age-matched peers on the PPVT when administered via the iPad®?

Hypothesis: The researcher hypothesized the children with ASD would perform the same or better than vocabulary age-matched children’s scores on iPad® PPVT.

Statistical Analysis: A repeated measures analysis of variance (ANOVA) was conducted to determine differences between iPad® PPVT test presentations among the matched pairs. The repeated measures ANOVA indicated a significant difference between iPad® PPVT scores of children with ASD and vocabulary age-matched peers, \( F(1,1) = 9.56, p = .01, \eta^2 = 0.44 \). The effect size was large. A difference was found, but not in the direction of the hypothesis. Therefore, the hypothesis was not supported. Descriptive statistics are presented in Table 4.2.
Table 4.2

Descriptive Statistics of iPad® PPVT Scores

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical</td>
<td>114.77</td>
<td>9.97</td>
<td>13</td>
</tr>
<tr>
<td>ASD</td>
<td>100.46</td>
<td>16.61</td>
<td>13</td>
</tr>
</tbody>
</table>

3) Are there differences in comprehension scores between children of different classification (vocabulary age-matched peers versus ASD)?

   Hypothesis: The researcher hypothesized there will be a difference.

   Statistical Analysis: A two-way, 2 (classification: vocabulary-aged matched peers and ASD) by 3 (comprehension scores for each modality: iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book) repeated measures multivariate analysis of variance (MANOVA) was conducted. Classification was the between subject variable and modality was the within subject variable. The two-way repeated measures MANOVA showed there was not a significant main effect for classification, $F(1, 24) = 3.68, p = 0.067, \eta^2_p = 0.13$. The effect size was medium. This means the hypothesis was not supported.

Results are presented in Table 4.3. Descriptive statistics are shown in Table 4.4.

Table 4.3

Two Way Repeated Measures MANOVA Summary Table for Between-Subjects Effects for Classification

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\eta^2_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>44353.85</td>
<td>1</td>
<td>44353.85</td>
<td>1015</td>
<td>.000</td>
<td>.98</td>
</tr>
<tr>
<td>Classification</td>
<td>160.82</td>
<td>1</td>
<td>160.82</td>
<td>3.68</td>
<td>.067</td>
<td>.13</td>
</tr>
<tr>
<td>Error</td>
<td>1048.67</td>
<td>24</td>
<td>43.69</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.4

Descriptive Statistics of a Two-Way Repeated Measures MANOVA for Classification and Comprehension Scores

<table>
<thead>
<tr>
<th></th>
<th>Classification</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPad® Read-To-Me</td>
<td>Typical</td>
<td>25.62</td>
<td>4.23</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>ASD</td>
<td>23.31</td>
<td>5.31</td>
<td>13</td>
</tr>
<tr>
<td>iPad® PI Reading</td>
<td>Typical</td>
<td>26.38</td>
<td>2.75</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>ASD</td>
<td>23.08</td>
<td>4.59</td>
<td>13</td>
</tr>
<tr>
<td>Traditional</td>
<td>Typical</td>
<td>23.85</td>
<td>4.51</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>ASD</td>
<td>20.85</td>
<td>6.22</td>
<td>13</td>
</tr>
</tbody>
</table>

4) Is there a difference in comprehension scores when children in both groups are read to with a different modality (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book)? In other words, is there a main effect for modality?

Hypothesis: The researcher hypothesized that children would perform best with the iPad® book with the read-to-me feature activated.

Statistical Analysis: A two-way, 2 (classification: vocabulary-aged matched peers and ASD) by 3 (comprehension scores for each modality: iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book) repeated measures multivariate analysis of variance (MANOVA) was conducted. There was a significant main effect for modality, $F(2, 23) = 3.89, p = 0.04$, Wilks’ $\Lambda = 0.747$, $\eta^2_p = 0.25$ as shown in Figure 4.1. Since there were three storybook modalities, a post hoc test with Bonferroni correction was conducted to determine exactly which means were significantly different in the main effect for modality. Results indicated that with all children included, children performed significantly better with
either iPad® condition compared to being read with a traditional book. iPad® read-to-me versus traditional $t(25) = 2.15, p = 0.04$, and iPad® read by PI versus traditional $t(25) = 2.76, p = 0.01$. The hypothesis was partially supported. In addition, results of the post-hoc paired samples t-test are shown in Table 4.5.

![Figure 4.1 Means of Story Comprehension Scores When Children are Read Three Storybooks in Different Modalities](image)

*Figure 4.1* Means of Story Comprehension Scores When Children are Read Three Storybooks in Different Modalities
Table 4.5

<table>
<thead>
<tr>
<th>Pair</th>
<th>Description</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>iPad® Read-To-Me - Traditional</td>
<td>2.15</td>
<td>25</td>
<td>.04</td>
</tr>
<tr>
<td>Pair 2</td>
<td>iPad® Read-To-Me - iPad PI Reading</td>
<td>-.29</td>
<td>25</td>
<td>.78</td>
</tr>
<tr>
<td>Pair 3</td>
<td>iPad® PI Reading – Traditional</td>
<td>2.76</td>
<td>25</td>
<td>.01</td>
</tr>
</tbody>
</table>

Note. \( n = 26 \)

5) Does an interaction exist between modality of book reading and child classification? (Is there a difference in how children with different classifications responded to comprehension questions with varying modalities of storybooks (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book))?

   Hypothesis: The researcher hypothesized that children with autism would respond better to the iPad® books than their vocabulary-age matched peers.

   Statistical Analysis: A 2 x 3 MANOVA indicated the interaction effect between modality of book reading and child classification was not statistically significant, \( F(2,23) = 0.13, p = 0.86 \), Wilks’ \( \Lambda = 0.99 \), \( \eta^2_p = 0.01 \). The hypothesis was not supported. Results are shown in figure 4.2.
Figure 4.2 Means of Story Comprehension Scores in Children with ASD and their Peers Across Three Storybook Modalities
CHAPTER V

Discussion

The purpose of this study was to investigate potential differences for children with ASD and their vocabulary-age matched counterparts between paper and tablet device versions of a standardized test of vocabulary comprehension and story comprehension scores with three different modalities of storybooks. In this chapter, results will be interpreted, including a description of how results support or refute previous research. Implications and possibilities for future research will be discussed.

Twenty-six children: 13 with a diagnosis of autism and 13 vocabulary-age-matched peers participated in the current study. Diagnosis of autism was verified through medical record and the CARS-2-ST (Schopler, Van Bourgondien, Wellman, & Love, 2010b) and CARS-2-HF (Schopler, Van Bourgondien, Wellman, & Love, 2010a) administered as a parent interview.

The PI administered both paper and iPad® versions of the PPVT to participants. In addition, participants were involved in shared storybook reading of three different modalities of storybooks: traditional, iPad® with the read-to-me feature activated, and iPad® with the PI reading the story. They answered questions based on Levels of Abstraction 1 and 2 (Blank, et al., 2003) about each story.

To summarize the results of the study, a paired sample t-test did not reveal a significant difference between iPad® and paper presentations of the PPVT in children with autism. However, there was a significant difference between the children with autism and their vocabulary-age-matched peers’ scores on the iPad® PPVT. When analyzing comprehension scores, in comparing the two participant groups of thirteen, there was no interaction between modality of book reading and child classification. However, when investigating the entire group
of twenty-six participants to determine whether there was a difference in comprehension scores when children in both groups are read to with a different modality (iPad® book with the read-to-me feature activated, iPad® book read by the PI, and traditional, paper book), it was found that there was a main effect for modality. Children performed significantly better with either iPad® condition compared to being read with a traditional book.

The next sections will provide a review of published research compared to results of the current study. Topics covered will include the following: research comparing Q-interactive® tablet and paper presentations, comparisons of scores among children with autism and their typically developing counterparts on computerized assessments, comparisons of scores among children with autism on paper and iPad® versions of the PPVT and other Q-interactive® tests, and story comprehension in young children with two iPad® stories and a traditional storybook.

**Comparison Between Tablet and Paper Tests**

To date, there is no known research comparing the PPVT on iPad® using the Q-interactive® digital platform and paper presentation of this test. Pearson, the publisher for Q-interactive®, has conducted equivalency studies between iPad® and paper versions on other assessments available in this format, except for the PPVT. The company indicates that an equivalency study was conducted for the CELF-5, and the PPVT is completed by examinees in a similar fashion (J. Henke, personal communication, 8-25-15). The company has published technical reports on administering the WISC-V intelligence test in both paper and Q-interactive® versions, which will be discussed in the next section. Limited research not tied to Pearson has examined other assessments using Q-interactive®.

More recently, research was conducted using Q-interactive® on the iPad® comparing performance on the WISC-V intelligence test among children with autism, children with ADHD,
and a typically developing matched control group (Raiford, Drozdick, & Zhang, 2015). Participants in the study were ages 6-16, and data collection occurred during the standardization of the WISC-V. Children with ASD performed significantly lower than the typically developing control group on the WISC-V iPad® version. Raiford et al. (2015) noted these results paralleled the results for the WISC-V paper version and aligned with previous research given the executive functioning challenges, verbal comprehension difficulties, and working memory deficits in children with ASD (Carnahan & Williamson, 2010; Englund, Decker, Allen, & Roberts, 2014; & Zenko, 2014).

Research, by individuals not affiliated with Pearson, using tests presented on the iPad® via Q-interactive® has investigated the administration of the Goldman Fristoe Test of Articulation, 3rd edition, (GFTA-3) a test for articulation (Buhr, Stricklin, Jones, & Nyquist, 2016). Buhr et al. (2016) investigated differences in scoring time, standard scores, and testing time between paper and iPad® versions when the GFTA-3 was administered to mostly typically developing children. Their results included the following: the iPad® version took less time to score than the paper version, there was no significant difference between standard scores on iPad® or paper versions, and no significant difference regarding testing time.

Results of the current study indicated there was not a significant difference in standard scores of children with ASD on the iPad® PPVT via Q-interactive® and the paper version of the PPVT. It is unknown whether experience with both the iPad® and paper testing materials at home and/or school may have influenced these results as all participants had some prior experience with the iPad® (See Appendix M). Experience with paper assessment materials was not measured in the current study. However, it should be noted there are no interactive features (sounds, visual effects, etc.) on Q-interactive®, rather, it is an iPad® format of the paper test. In
Summary, studies have shown no significant differences between paper and iPad® test presentations using Q-interactive®. The results of the current study concur with previous findings.

Comparison Between Typical Peers and Children with ASD on Tests Administered via Technology

Research comparing performance of typical peers to performance of children with ASD on tests using a technology format was first examined using computers, prior to the advent of tablet devices. One such study was conducted by Alt and Moreno (2012). In fact, Alt and Moreno’s study was similar to the current one with both typically developing children and children with ASD; however, differences exist in participants’ chronological age and matching of the participant groups. Alt and Moreno included older children, ages 5 to 13, while the current study included children with ASD ages 4-6. With respect to matching of participants, Alt and Moreno matched participants on gender and chronological age (+/-12 months), and the current study matched participants on gender and vocabulary age (+/- 6 months).

Alt and Moreno compared presentation of the ROWVT and EOWVT on the computer using scanned test plates to traditional, paper presentations of these tests. Alt and Moreno found no significant difference between the two test formats for either participant group. While the current study used iPad® presentation rather than computer presentation, analogous results were achieved in that there were no significant differences between the two types of test presentations for children with ASD.

In the current study, while the researcher hypothesized that children with ASD would perform significantly better than their vocabulary-age-matched peers on the iPad® form of the PPVT, this was not the case. This hypothesis was built upon the evidence indicating children
with ASD demonstrate strengths in processing visual stimuli (ASHA, 2006; Janzen & Zenko, 2012; Lanter et al., 2012; & Lanter & Watson, 2008) and have a strong interest in technology (Caron & Shane, 2014; Goodwin, 2008; & Shane & Albert, 2008). Furthermore, research has indicated the visual aspects of technology align with the visual processing assets in ASD (Shane & Albert, 2008). While there is some empirical evidence to suggest that visual strengths exist in children with ASD, it may have been pretentious to hypothesize children with ASD would outperform their vocabulary-age-matched peers. The current study indicated there was a significant difference between the scores of the vocabulary-age-matched children and those with ASD; the vocabulary-age-matched children scored significantly higher than the children with ASD did. This finding aligns with previous research, including that of Raiford et al. (2015). It should be noted that the Q-interactive® test presentation on the iPad® contains no animation or other attempts at interactive features, rather it is only a different visual presentation of standardized tests. This may suggest that administering assessments on an iPad® will produce similar results to administering assessments in paper format.

**Children with ASD and the iPad® PPVT**

In 2013, Knight et al. indicated a “critical need” (p. 2645) for research using technology, particularly tablet technology, with children with ASD. Ennis-Cole (2015) echoed Knight et al. (2013), stating technology use for children with ASD is a relatively “young science” (p. 38). Much of the currently available research related to technology and children with autism has been conducted with computers.

One of the few studies conducted concerning testing in iPad® format with children with autism was completed by Pearson, the publisher of Q-interactive®. Daniel (2013) a senior scientist for research innovation with Pearson, completed a survey of practitioners who had used
the Q-interactive®, iPad® version of the WISC-V, an intelligence test. The respondents were asked about the use of Q-interactive® with different diagnostic groups and the groups’ responses to the iPad® testing versus “paper and pencil tests” (p. 3). Ninety-five professionals responded, with 34 of them reporting using the iPad® with individuals with autism. Of the 34, 20 participants indicated that testing via Q-interactive® influenced examinees’ behavior. From the 20, 17 specified the examinees were more engaged with the iPad®.

Additionally, Daniel (2013) asked professionals in the survey to elaborate on other behaviors noticed when using Q-interactive® with examinees diagnosed with autism. Daniel noted “many commented that examinees were more engaged with the assessment process because Q-interactive® seemed more game-like” (p.10). However, some survey respondents indicated that this “game-like” feature of Q-interactive® diverted examinees’ attention as they wanted to play games on the iPad® instead of participate in the assessment on the Q-interactive® app. Overall, Daniel’s (2013) results should be interpreted with caution, as there was not an engagement measure used, rather these results were obtained from clinician report.

The current study found there was no significant difference in performance of children with autism on iPad® and paper versions of the PPVT, but engagement was not measured. However, similar to the findings of Daniel (2013), the PI noted because children with ASD seem to have a fascination with technology and knowledge in the operating system of the iPad®, they frequently requested to play games or look at other apps on the iPad®. This fascination with and knowledge of the iPad® has also been cited by Caron and Shane (2014). Testing was videotaped and this information could be reviewed in future studies.

Similar to the availability of the iPad® for diagnostic testing, the availability of the iPad® has created a new way for literature to be presented to children. Few studies have examined
children with autism who are emergent readers gaining access to books via the iPad® in order to answer story comprehension questions. Rather, most studies have investigated children with autism who are conventional readers, reading for themselves to obtain content from storybooks (Fleury et al., 2014; Lanter et al., 2012). In general, technology interventions for children with autism are considered to be “emerging” rather than “established” treatment approaches (National Autism Center, 2015).

**Storybook Comprehension**

Before discussing the use of comprehension questions during shared storybook reading with the iPad®, it is important to recognize previous research conducted in this area using traditional, paper materials. Reese et al. (2003) and Senechal et al. (1995) indicated that it is more beneficial to have the child actively involved during reading (e.g. answering questions about the storybook) than passive participation. To promote active participation, the researcher used story comprehension questions modeled after Blank et al. (2003) throughout the storybook readings, rather than at the end of the stories.

The research, described in chapter two, by Blank et al. used a hierarchy of language abstraction to develop story comprehension questions. The four levels of increasing complexity of language abstraction include the following: matching, selective analysis, reordering, and reasoning. In the current study, only the first two levels were used. A brief description with examples of those two levels of questions follows. The first level is known as matching questions since the language to answer the questions is found by looking at pictures in the book, such as “show me the flower” when the flower is closely pictured. Selective analysis questions require prior knowledge from experiences and ask about less obvious features of objects such as attributes (e.g. “What color is the cup?”), location (e.g. “Where is Bob?”), and functions (e.g.
“Show me what mom uses to dig.”) The researcher tested questions at the first two levels of abstraction in a pilot study and determined there were no differences in the questions across the three storybook presentations. In addition, all participants completed a screening, of Levels 1 and 2 as part of the eligibility criteria.

Studies comparing traditional and electronic books, to date, have primarily focused on the use of the computer rather than the iPad®. Additionally, the limited research conducted related to the use of iPad®s for story comprehension for children with autism has primarily included participants who are school-aged, such as the study conducted by Price (2011) with middle school, high school, and 18-22 year-old students with autism. Price found the students answered comprehension questions with greater accuracy using an e-book on the iPad® than reading from a traditional paper story. Participants in this study were at minimum four grade levels behind in reading. Overall, comprehension accuracy increased by 21% for middle school students and 25% for high school students using the iPad® compared to traditional paper story. Teachers administering the comprehension questions completed a questionnaire at the conclusion of the study and reported students participated in fewer off-task behaviors.

In the current study, two questions were asked about the use of iPad® tablets for children’s responses to story comprehension questions. First, the PI investigated whether children in both groups demonstrated a difference between accuracy of response to reading comprehension questions during shared book reading across three different modalities: iPad® with the read-to-me feature activated, iPad® with the PI reading, and a traditional, paper book. Second, the PI aimed to find whether a difference existed in all 26 participants’ accuracy of response to story comprehension questions by modality, determining whether there was a main effect for modality.
Comprehension of iPad® and Paper Storybooks

Both children with autism and vocabulary-age-matched peers performed significantly better on story comprehension questions with both iPad® modalities compared to the traditional, paper book modality. The iPad® story read by the PI only differed from the traditional, paper storybook by display on the iPad® rather than paper. It did not use any special features; however, the iPad® with the read-to-me feature did include special features, which are discussed in the next section.

Comprehension with the iPad® with the read-to-me feature

In this version of the iPad® story, a pre-recorded voice within the iBooks app read the story. As the story was being read, the words were highlighted blue. Additionally, there were sound effects on select pages of the story related to the storyline (e.g. eating and drinking sounds when Pete the Cat and his mom had a picnic). This format aligns with previous research by Bus, Verhallen, and de Jong (2009), and van den Broek, et al., (2009) who indicated animation, sound effects, and other features of e-books on computers are beneficial when they parallel the text of the story, rather than features un-essential to the storyline, which can lead to cognitive overload (Bus, et al., 2015). No known research has been conducted looking at preschoolers’ story comprehension skills with the read-to-me feature on the iPad® prior to the current study.

It was noted by the PI that the participants with autism tracked the print with their eyes as words turned blue during the iPad® presentation with the read-to-me feature activated. While the PI did not use this information as a measure of the participants’ engagement with the iPad®, there is potential for future research.

Given the lack of a significant difference in the way the participants with different classifications responded to the varying modalities (no interaction between modality of book and
child classification) the current study may indicate that books on the iPad® function in similar ways for typically developing children and children with autism. Therefore, when analyzing the group of 26 participants together, there was a significant difference in comprehension scores with the iPad® (significant main effect for modality), meaning it is possible both groups performed better with the iPad® storybook presentations than the traditional storybook presentation due to more exposure to technology than paper materials. These results may indicate when working with young children there is the potential that children who have historically not performed well with paper materials may be able to complete tasks with more success using an iPad®.

As the current study examined children with ASD, it is important to acknowledge strategies professionals should consider when assessing children with autism.

When testing children with ASD, there are several factors professionals must consider among them are cognitive characteristics of children with ASD, use of the iPad® for non-academic purposes, and the differences between treatment and assessment situations.

**Cognitive Characteristics**

In the area of executive functioning, during the current study, it was observed that some participants had difficulties carrying out goals, implementing cognitive flexibility, and inhibiting negative thoughts. The first example described here demonstrates difficulty in the area of executive functioning, specifically cognitive flexibility and inhibition as the child had some difficulty blocking negative thoughts toward bananas, even though the scenario in the storybook was fictitious. The second example described in this section indicates adjustments the PI used to assist participants with ASD in completing the goals of the research session and suggestions for professionals testing children with ASD.
First, although the researcher inquired about food allergies, food preferences, and diet restrictions in regard to the snack reinforcement given at the end of each research session, the researcher was unaware of and therefore did not ask parents about potential food aversions as related to the traditional storybook *Pete the Cat and the Bad Banana*. Unknown to the researcher until a research session and reading of the storybook, one of the participants did not like bananas. Subsequently, upon discovery of this information, the researcher allowed the child to take an extended break during the reading of *Pete the Cat and the Bad Banana*, and covered one picture of the “bad banana” in the story as doing so did not impact answering of any story comprehension questions. The participant’s mother was informed of this following the research session, and she indicated the child did not like bananas, having an aversion to them at home. She apologized for not indicating to the researcher that her child has an aversion to bananas, but was unaware of the storybook’s theme prior to the research session.

Second, when administering the iPad® PPVT, some children had difficulty carrying out the goal of completing this assessment because it does not have a clear ending. The endpoint is reached once children answer eight questions incorrectly in a set of twelve, reaching the ceiling for the assessment. Therefore, it is difficult to inform the children of the number of items remaining. To assist children with ASD in continuing to work toward completion of this task, when needed, children were given one block to build a structure or peg to put into a pegboard for each pointing response the children completed on the iPad® PPVT. This procedure provided the children with a clearer goal-oriented activity of filling the pegboard or completing the structure.
Use of the iPad® for Non-Academic Purposes

During data collection sessions, the researcher noted multiple children (in both groups) requested to play games. Since children are accustomed to using iPad®s for this purpose, they may believe gaming is the only purpose of the device. However, in the educational setting, the iPad® can be used for other objectives. Focusing on tasks that are more academic might be difficult for children with autism given their visual strengths and knowledge of the operating features of the iPad®. Therefore, using a social story may be helpful for children with autism to explain the purpose of the iPad®.

Differences Between Assessment and Intervention

Intervention allows for more adaptations than research, as research requires specific protocols be followed. Due to the requirements of the current study, some children did not qualify. In particular, some participants needed additional time with traditional books, and they were somewhat successful after multiple attempts with breaks in between each attempt, but tired after the multiple attempts to finish the story. If the procedures in the study took place during a regular treatment session, time could be extended beyond two sessions to accommodate the children’s needs.

Considerations for Story Comprehension Questions for All Children

Finally, in working with all young children on story comprehension questions, it is essential for educational professionals to be aware of multiple potential answers to multiple meaning words. As an example, in the traditional story, Pete the Cat and the Bad Banana one question was “Show me the ice cream scoop.” Some participants pointed to a scoop of ice cream in the banana split and some pointed to the ice cream scoop utensil. Both are a reference to the ice cream scoop, but one is a utensil and the other is a scoop of ice cream. Thirty-one percent or
4 out of 13 children with ASD received all points for this question, 38% or 5 out of 13 children with ASD pointed to the scoops of ice cream in the dish, and the other 31% or 4 out of 13 children provided a different, incorrect response to the question. In the vocabulary-age-matched group, 38% or 5 out of 13 children received all points for this question, pointing at the utensil. Another 4 out of 13 or 31% of children pointed to one scoop of ice cream in the dish, and 3 out of 13 (23%) children pointed to all three scoops of ice cream in the dish. Finally, 1 out of 13 or 8% of the vocabulary-age-matched children gave an incorrect response (pointed to the whipped topping). It is possible that this multiple meaning (van Kleeck & Shuele, 1987) word influenced results for both children with autism and vocabulary-age-matched peers. The responses to this question may have influenced results for the traditional storybook presentation condition; however, no other vocabulary was misidentified.

**Implications**

There are multiple opportunities for children in preschool and early elementary to use iPad® tablets both at school and at home due to the proliferation of technology in our society. The current study has implications for speech-language pathologists, teachers, and families as they select between paper and iPad® based assessments and storybooks. In this study, findings demonstrated iPad®s were more effective than paper materials when asking story comprehension questions during shared storybook reading. This was true for both the children with ASD and their vocabulary-age-matched counterparts.

Regarding assessment, the PPVT Q-interactive® format and paper format are potentially equivalent test forms, supporting Pearson’s claims that no differences exist between the test formats. Children who have experience with the iPad® may respond in a similar manner to assessments on the iPad as they do to assessments on paper. Therefore, when speech-language
pathologists are selecting assessment tools, the Q-interactive® platform is one format that should be considered, if available.

Implications for iPad® storybooks overall include the iPad® may be helpful for children with autism and typically developing children. Teachers and speech-language pathologists may consider the use of iPad® storybooks if the students have previously responded positively to iPad® for other purposes, since the iPad® is equally if not more effective as traditional, paper books. Furthermore, professionals should consider allowing children to make choices on which storybook presentation they would prefer, since each presentation is equally effective. Children may be more motivated to participate in shared reading if they are permitted to select the storybook modality. Educational professionals should ask parents about children’s experiences with and motivation by the iPad® to make appropriate intervention decisions.

Since children with ASD have a strong interest in technology (Caron & Shane, 2014; Goodwin, 2008; & Shane & Albert, 2008), it is important to know about how the iPad® is used at home for purposes other than looking at books, such as gaming, and watching videos. It is possible children with ASD are more accustomed to passive activities with the iPad® rather than the interaction component. However, the current study indicated children with ASD performed no differently on story comprehension questions with the iPad® reading the words or the PI reading.

Limitations

The small sample size may have limited statistical analysis. Given the requirements of the study for participants with autism to be verbal, pass a language screening, and score no more than one and a half standard deviations below the mean on the PPVT, the pool of possible participants for the study was narrow. It is unknown how participants not meeting the study
requirements would perform on iPad® tasks, particularly children who are not verbal, but who could complete a test of vocabulary comprehension. Considering the small sample size, there are several available directions for future research. The next section will describe opportunities to expand research in the area of literacy learning in young children with autism, using the iPad® as a tool.

An additional potential limitation in participant recruitment for both groups may have been the time commitment (two sessions) which may have hindered some families from having their child participate and may have caused some families/participants to drop out.

Even with the parent interview and information from the CARS (CARS-2-HF; Schopler, Van Bourgondien, Wellman, & Love, 2010a; CARS-2-ST; Schopler, Van Bourgondien, Wellman, & Love, 2010b) about the types of supports and environmental structure the participants needed to succeed, the environment may have limited performance. While the researcher made every effort to use a structured, non-distracting environment (e.g. use of the work system with visuals, break activities in an opaque plastic container, removing the clock/other distracting items from the therapy room) to assist the participants with autism, the new environment and interactions with an unfamiliar adult may have decreased performance.

Although parents were asked about experience with the iPad®, shared book reading at home, and exposure to Pete the Cat books, not directly observing this information may have impacted results. For example, because parents were aware this study was investigating the use of books on the iPad®, they may have answered questions in a way they thought the researcher would like them to answer. In addition, while the parents reported on the reading of Pete the Cat occurring at home, the amount of exposure to the Pete the Cat book series at the participant’s school was sometimes unknown.
During data collection with both iPad® stories, the turn-my-page feature was turned off to allow the child to turn the pages in the story. While each participant was given instructions, prior to each storybook presentation, to wait to turn the page until after the researcher asked a question, this presented a limitation. At times, the PI had to quickly ask the question before turning the page or go back to the previous page to ask the question if the participant turned the page too rapidly. However, if the turn-my-page feature were turned on, it would have been more difficult to ask questions, as the story would be read straight through without permitting any natural pauses for questions. Adjusting features of the iPad® book is a consideration professionals must look into in advance of using an electronic storybook with children as suggested by Bus et al., (2009).

**Future Directions**

Following this dissertation research, the need for additional research in the area of iPad® technology for use with children with autism continues. This area of research remains a “young science” (Ennis-Cole, 2015), and while there are several possibilities for future studies, the author has identified four primary areas for additional research. These areas include the following: expand the participant pool in the current study, repeat the current study with different classifications of participants, further investigate engagement of children with the iPad®, and determine whether reinforcement techniques on the iPad® (such as animation or sound) influence children’s story comprehension scores. Detailed descriptions of each of these four future directions will follow.

First, with the small sample size in the current study, and the dearth of research in the area of story comprehension using iPad® book presentations, it would be beneficial to expand this study to include more participants with autism. Future studies may broaden the participant
sample by investigating how children who use an augmentative alternative communication (AAC) device would score on story comprehension questions when a book is presented on the iPad®.

Second, future studies should investigate engagement and/or distractibility of both typically developing children and children with ASD when given an iPad® book versus a traditional book. Engagement with the iPad® during testing using Q-interactive® should also be studied as more information is needed using measures other than clinical judgment.

Third, to expand upon the work of Moore and Calvert, future research should consider the use of visual (animation) and/or sound reinforcement to provide feedback on accuracy of response to story comprehension questions on the iPad®. From the current study, it is unknown whether appropriate animation would make a difference in children’s story comprehension scores. Finally, other classifications of participants such as children with specific language impairment, children from low socioeconomic status, children who are English language learners, and children from different geographical regions should be investigated to generalize results to the population.
REFERENCES
REFERENCES


77


Robertson, S. (2013). *Building Better Readers: The complete guide to literacy development for SLPs.* Indiana, PA: Dynamic Resources, LLC.


Date: November 24, 2015

Principal Investigator: Kathy Strattman Co-Investigator(s): Karissa Marble Department: CSD
IRB Number: 3534 Review Category: FULL

The Wichita State University Institutional Review Board (IRB) has reviewed your research project application entitled, “Comprehension Scores Among Typical Preschoolers and Preschoolers with Autism: Traditional and Tablet-Based Storybooks”. The IRB approves the project according to the Federal Policy for the Protection of Human Subjects. As described, the project also complies with all the requirements and policies established by the University for protection of human subjects in research.

This approval is for a period of one year from the date of this letter and will require continuation approval if the research project extends beyond November 23, 2016.

Please keep in mind the following:

1. Any significant change in the experimental procedure as described should be reviewed by the IRB prior to altering the project.
2. When signed consent documents are required, the principal investigator must retain the signed consent documents for at least three years past completion of the research activity.
3. At the completion of the project, the principal investigator is expected to submit a final report.

Thank you for your cooperation. If you have any questions, please contact the IRB Administrator at IRB@wichita.edu.

Sincerely,

Michael Rogers, Ph.D. Chairperson, IRB
Hello. This is Karissa Marble, PhD student at Wichita State University. With whom am I speaking? Thanks for calling to inquire about my research study using iPad®s and paper books.

Please note that you are under no obligation to participate in this research study. If at any time you have questions, please feel free to ask. You will complete a formal consent document with your signature when you and your child come to WSU for the actual testing session. Do I have your permission to ask you some questions to determine if your child is able to participate in this study?

**Preliminary phone interview questions for all parents (5 min.)**

1) Has your child read any books in the Pete the Cat book series?
2) Tell me about what your story time routine with your child looks like.

3) Has your child passed vision and hearing screenings?

**Preliminary phone interview questions with parents of children with autism spectrum disorders (20 min.)**

4) How did your child receive his diagnosis?

5) Describe how your child communicates. Does he communicate verbally?

6) What classroom supports (e.g. daily picture schedule)/services (e.g. speech therapy, occupational therapy) does your child receive? What is the frequency/duration of these services?

**Other questions for all participants:**

7) Does your child have any experience using the iPad®?

8) If so, does he/she use any books on the iPad®?

9) Does your child have any allergies or food preferences? (I ask this because I provide a snack.)
(In response to question 1—eliminate from study) Since your child is very familiar with the Pete the Cat book series, I am unable to include you in this research study. However, I appreciate your time today.

(In response to question 3—eliminate from study) Since your child did not pass vision and hearing screenings or wears glasses/hearing aids, I am unable to include you in this research study. However, I appreciate your time today.

(In response to question 4—eliminate from study) I greatly appreciate your time, but for this study I need participants who communicate without the use of communication systems.

I would like to schedule a testing session with you and your child. This session will take place at the WSU Speech-Language-Hearing Clinic in the Metroplex at 29th and Oliver. Please arrive at door T. When is a convenient time for you?

Thanks for your time. I look forward to seeing you on (date/time). Please bring documentation of your child’s diagnosis (if applicable) with you on this date.
Researcher says: *I am going to show you some pictures and we will talk about the pictures.*

**Criterion Score:** Level 1: 80% at the adequate level, 4/5; Level 2: 60% at the adequate level, 3/5

<table>
<thead>
<tr>
<th>Screening Item #</th>
<th>Examiner Says:</th>
<th>Correct Answer</th>
<th>Blank’s Level 1 or 2 Question</th>
<th>Receptive (R) or Expressive (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Show me the hamburger.</td>
<td>(Child points to picture of the hamburger.)</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>What is this?</td>
<td>donut</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>3</td>
<td>What is the boy doing?</td>
<td>Brushing his teeth</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>4</td>
<td>Show me the boy in the bathtub.</td>
<td>Child points to picture of boy in bathtub.</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>5</td>
<td>Show me the one that is pink.</td>
<td>Child points to scissors with pink handle.</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>Look at these pictures. Point to the one we put on our foot.</td>
<td>Boot</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>7</td>
<td>Who is this?</td>
<td>Doctor</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>8</td>
<td>What is happening in this picture?</td>
<td>It’s raining</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>9</td>
<td>Where is the duck swimming?</td>
<td>In the water</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>This is a pencil. Show me another pencil.</td>
<td>Child points to 2nd pencil</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>11</td>
<td>These grapes are purple. What other color can grapes be?</td>
<td>Green Red Brown (next category)</td>
<td>3</td>
<td>E</td>
</tr>
<tr>
<td>12</td>
<td>Show me the one not used for writing.</td>
<td>Scissors</td>
<td>3</td>
<td>R</td>
</tr>
<tr>
<td>13</td>
<td>Why do people need to eat food?</td>
<td>So they aren’t hungry, to live/survive, to stay healthy</td>
<td>4</td>
<td>E</td>
</tr>
<tr>
<td>14</td>
<td>What could we use when we are hurt?</td>
<td>Band-Aid</td>
<td>4</td>
<td>R</td>
</tr>
</tbody>
</table>
APPENDIX D

STORYBOOK SCORING GUIDELINES

<table>
<thead>
<tr>
<th>Rating</th>
<th>Guideline</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Adequate (FA)</td>
<td>Response fully meets the demands of the task.</td>
<td>3</td>
</tr>
<tr>
<td>Acceptable (AC)</td>
<td>Response is correct but poorly formulated, imprecise, or includes extraneous information.</td>
<td>2</td>
</tr>
<tr>
<td>Ambiguous (AM)</td>
<td>Response is formulated in a way that makes it unclear whether it is correct or incorrect.</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate (IA)</td>
<td>Response does not meet the demands of the task or no response is offered.</td>
<td>0</td>
</tr>
</tbody>
</table>

Consent Form

Purpose: Please note: As you have completed the phone interview, this is formal documentation of your full consent to participation in this study. Your child is invited to participate in a research study comparing vocabulary tests and storybook questions using both traditional paper and iPad books.

Participant Selection: Your child was selected as a possible participant in this study because your child has a diagnosis of autism and can independently look at a book and iPad. Approximately 30 participants will be invited to join this study. Additionally, you will provide documentation of medical diagnosis of autism and documentation that your child’s vision and hearing are within normal limits.

Explanation of Procedures: If you decide to participate, you and your child will do the following:

Screening (Day 1)
*This is completed to decide whether your child meets the requirements for the study (Day 2); your child may be included in day 2 testing if his/her vocabulary score is within normal limits (1.5 standard deviations from the mean). *
1) Paper picture vocabulary tests 15 min.
2) 10 min. test to assess language level

Test Day (Day 2)
With your child:
1) PhD student researcher will read paper book, Pete the Cat and the Bad Banana (15 min.)
2) PhD student researcher will read the iPad book, Pete the Cat: Too Cool for School (15 min.)
3) The iPad will read the book, Pete the Cat: Pete at the Beach to the child (15 min.) (counterbalanced)
4) Picture vocabulary test on iPad (13 min.)

With you:
1) The PhD student researcher will ask some questions while your child listens to and answers questions about the books.
Please note that both sessions with your child (day 1 & day 2) will be video recorded.

**Discomfort/Risks:** There are minimal anticipated risks related to participating in this study. If your child feels uncomfortable with a question about the story or the vocabulary pictures, he/she will be told that he/she may skip the question and go on. The child may skip the question or request to take a break.

**Benefits:** Research on reading comprehension in children with autism is 30 years behind overall reading comprehension research (Koppenhaver, 2010). Therefore, this study may be helpful for parents, teachers, and speech-language pathologists as it will provide information about the use of iPads for answering questions about books and the use of iPads for vocabulary picture tests. This will be beneficial to society as iPads and other tablet technology are widely used by educators and families on a daily basis; however, few studies have been conducted comparing their use with traditional materials.

**Confidentiality:** Every effort will be made to keep your study-related information confidential. However, in order to make sure the study is done properly and safely there may be circumstances where this information must be released. By signing this form, you are giving the research team permission to share information about you with the following groups:

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Wichita State University Institutional Review Board;
- The Gaulter Grant Committee in the College of Health Professions

The researchers may publish the results of the study. If they do, they will only discuss group results. Your name will not be used in any publication or presentation about the study. Each session will be video-recorded and video recordings may be used at professional conferences; however, as mentioned, you and your child’s name will not be used in the videos shown at professional conferences. The video recordings will be kept in a locked cabinet in Dr. Kathy Strattman’s office in Ahlberg Hall. The video recordings will be stored for a period of five years before they are destroyed.

**Payment to Subjects:**
At the end of each session, we would like to give your child a snack of his/her choosing. Additionally, at the end of the study (two sessions) we would like to give you (the parent) a $20.00 gift card for your child to a store he or she chooses. If you discontinue after the first testing session, you will receive a $10.00 gift card. Study payments are taxable income. Therefore, the gift card will be given to you and you will be asked to complete a W9 form, which requires your name, address, and social security number in order for you to receive study payments. A Form 1099 will be sent to you and to the Internal Revenue Service if your payments are $600 or more in a calendar year.
**Refusal/Withdrawal:** Participation in this study is entirely voluntary. Your decision whether or not to participate will not affect your future relations with Wichita State University. If you agree to participate in this study, you are free to withdraw from the study at any time without penalty.

**Compensation or Treatment for Research Related Injury:** Wichita State University does not provide medical treatment or other forms of reimbursement to persons injured as a result of or in connection with participation in research activities conducted by Wichita State University or its faculty, staff, or students. If you believe that you have been injured as a result of participating in the research covered by this consent form, you can contact the Office of Research and Technology Transfer, Wichita State University, Wichita, KS 67260-0007, telephone (316) 978-3285.

**Contact:** If you have any questions about this research, you can contact me or my faculty mentor at: Karissa Marble-Flint, 1845 N. Fairmount St., Wichita, KS 67260, 316-978-7262, kjmarble-flint@shockers.wichita.edu OR Kathy Strattman, Faculty Mentor, 1845 N. Fairmount St., Wichita, KS 67260, 316-978-6356, Kathy.Strattman@wichita.edu. If you have questions pertaining to your rights as a research subject, or about research-related injury, you can contact the Office of Research and Technology Transfer at Wichita State University, 1845 Fairmount Street, Wichita, KS 67260-0007, telephone (316) 978-3285.

You are under no obligation to participate in this study. Your signature below indicates that:
- You have read (or someone has read to you) the information provided above,
- You are aware that this is a research study,
- You have had the opportunity to ask questions and have had them answered to your satisfaction, and
- You have voluntarily decided to participate.
APPENDIX E (continued)

You are not giving up any legal rights by signing this form. You will be given a copy of this consent form to keep.

__________________________
Printed Name of Child

__________________________
Printed Name of Parent

__________________________ Date
Signature of Parent

__________________________
Printed Name of Witness

__________________________ Date
Witness Signature
Consent Form

Purpose: Please note: As you have completed the phone interview, this is formal documentation of your full consent to participation in this study. Your child is invited to participate in a research study comparing vocabulary tests and storybook questions using both traditional paper and iPad books.

Participant Selection: Your child was selected as a possible participant in this study because your child is a typically developing three-, four-, or five-year-old with normal vision and hearing and no diagnosis of a developmental disability or speech-language disorder. Approximately 30 participants will be invited to join the study.

Explanation of Procedures: If you decide to participate, you and your child will do the following:

Screening (Day 1)
*This is conducted to determine whether participants qualify for testing (Day 2). * (Your child may be included in day 2 testing if his/her vocabulary score is within normal limits (1.0 standard deviations from the mean). *

1) Paper picture vocabulary tests 15 min.
2) 10 min. screener modified from the Preschool Language Assessment Inventory (PLAI) to assess language level

Test Day (Day 2)
1) Read traditional book, Pete the Cat and the Bad Banana by PhD student researcher (15 min.)
2) Read iPad book, Pete the Cat: Too Cool for School by PhD student researcher (15 min.)
3) Read iPad book, Pete the Cat: Pete at the Beach, with “read to me” feature turned on (iPad reads story to child) (15 min.)
4) Picture vocabulary test on iPad (13 min.)
APPENDIX F (continued)

Please note that both sessions (day 1 & day 2) will be video recorded.

**Discomfort/Risks:** There are minimal anticipated risks associated with participating in this study. If your child feels uncomfortable with a question about the story or the vocabulary pictures, he/she will be told that he/she may skip the question and go on. The child may skip the question or request to take a break by pointing to a picture to indicate their choice.

**Benefits:** This study may be beneficial for parents, teachers, and speech-language pathologists as it will provide information about the use of iPads for answering questions about books and the use of iPads for vocabulary picture tests. This will be beneficial to society as iPads and other tablet technology are widely used by educators and families with young children on a daily basis; however, few studies have been conducted comparing their use with traditional materials.

**Confidentiality:** Every effort will be made to keep your study-related information confidential. However, in order to make sure the study is done properly and safely there may be circumstances where this information must be released. By signing this form, you are giving the research team permission to share information about you with the following groups:

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Wichita State University Institutional Review Board;
- Gaulter Grant Committee in the College of Health Professions

The researchers may publish the results of the study. If they do, they will only discuss group results. Your name will not be used in any publication or presentation about the study. Each session will be video-recorded and video recordings may be used at professional conferences; however, as mentioned, you and your child’s name will not be used in the videos shown at professional conferences. The video recordings will be kept in a locked cabinet in Dr. Kathy Strattman’s office in Ahlberg Hall. The video recordings will be stored for a period of five years before they are destroyed.

**Payment to Subjects:**
At the end of each session, we would like to give your child a snack of his/her choosing. Additionally, at the conclusion of the study we would like to give you (the parent) a $20.00 gift card for your child to a store he or she chooses. If you withdraw after the first testing session, you will receive a $10.00 gift card. Study payments are taxable income. Therefore, the gift card will be given to you and you will be asked to complete a W9 form, which requires your name, address, and social security number in order for you to receive study payments. A Form 1099 will be sent to you and to the Internal Revenue Service if your payments are $600 or more in a calendar year.
APPENDIX F (continued)

Refusal/Withdrawal: Participation in this study is entirely voluntary. Your decision whether or not to participate will not affect your future relations with Wichita State University. If you agree to participate in this study, you are free to withdraw from the study at any time without penalty.

Compensation or Treatment for Research Related Injury: Wichita State University does not provide medical treatment or other forms of reimbursement to persons injured as a result of or in connection with participation in research activities conducted by Wichita State University or its faculty, staff, or students. If you believe that you have been injured as a result of participating in the research covered by this consent form, you can contact the Office of Research and Technology Transfer, Wichita State University, Wichita, KS 67260-0007, telephone (316) 978-3285.

Contact: If you have any questions about this research, you can contact me or my faculty mentor at: Karissa Marble-Flint, 1845 N. Fairmount St., Wichita, KS 67260, 316-978-7262, kjmarble-flint@shockers.wichita.edu OR Kathy Strattman, Faculty Mentor, 1845 N. Fairmount St., Wichita, KS 67260, 316-978-6356, Kathy.Strattman@wichita.edu. If you have questions pertaining to your rights as a research subject, or about research-related injury, you can contact the Office of Research and Technology Transfer at Wichita State University, 1845 Fairmount Street, Wichita, KS 67260-0007, telephone (316) 978-3285.

You are under no obligation to participate in this study. Your signature below indicates that:

- You have read (or someone has read to you) the information provided above,
- You are aware that this is a research study,
- You have had the opportunity to ask questions and have had them answered to your satisfaction, and
- You have voluntarily decided to participate.

You are not giving up any legal rights by signing this form. You will be given a copy of this consent form to keep.

Printed Name of Child

Printed Name of Parent

__________________________  Date
Signature of Parent

__________________________
Printed Name of Witness

__________________________  Date
Witness Signature
## APPENDIX G

**QUESTIONS FOR PETE THE CAT: PETE AT THE BEACH,**  
*iPAD® BOOK WITH THE READ-TO-ME FEATURE ACTIVATED*

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Page Number</th>
<th>Question</th>
<th>Blank’s Level</th>
<th>Expressive (E) or Receptive (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>What is this? (car)</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Here is Pete the Cat. Show me another cat.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>Where is Bob?</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>What does mom use to dig? (shovel)</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>Show me the wave</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>Bob is surfing. What other things could you do in the water?</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
<td>What game are mom and Pete playing? (catch, ball)</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
<td>Bob is on the surfboard. Where is Pete?</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>9</td>
<td>24</td>
<td>Show me the cat on the surfboard.</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>What are Pete &amp; Bob doing? (surfing)</td>
<td>1</td>
<td>E</td>
</tr>
</tbody>
</table>
## APPENDIX H

### QUESTIONS FOR PETE THE CAT AND THE BAD BANANA, TRADITIONAL BOOK

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Page Number</th>
<th>Question</th>
<th>Blank’s Level</th>
<th>Expressive (E) or Receptive (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4/5</td>
<td>Here is a banana. Show me another banana.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>What is this? (bread)</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>Show me what Pete uses to spread the peanut butter.</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>What’s in the oven? (bread)</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>Show me the ice cream scoop.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>Where is Pete standing? (on the chair)</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>An orange is a fruit. Tell me another fruit.</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
<td>Show me the hot dog.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>9</td>
<td>25</td>
<td>What are these? (shoes)</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>29</td>
<td>Show me the one we eat. (banana)</td>
<td>2</td>
<td>R</td>
</tr>
</tbody>
</table>
## APPENDIX I

**QUESTIONS FOR PETE THE CAT: TOO COOL FOR SCHOOL.**

iPad® Book Read by the Pi

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Page Number</th>
<th>Question</th>
<th>Blank’s Level</th>
<th>Expressive (E) or Receptive (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>What is this? (shoe)</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Here is a shirt. Show me another shirt.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>Show me something we eat. (banana)</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>Where are the teacher’s glasses?</td>
<td>2</td>
<td>E/R</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>Show me Pete the Cat.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
<td>What is happening in this picture? (driving bus)</td>
<td>2</td>
<td>E</td>
</tr>
<tr>
<td>7</td>
<td>17</td>
<td>Which socks are bigger?</td>
<td>2</td>
<td>E/R</td>
</tr>
<tr>
<td>8</td>
<td>22/23</td>
<td>Here is a baseball hat. Find one like this.</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>9</td>
<td>22</td>
<td>What is this? (baseball/ball)</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>28</td>
<td>Show me the one we put on our feet. (boots)</td>
<td>2</td>
<td>R</td>
</tr>
</tbody>
</table>
APPENDIX J

WORK SYSTEM
APPENDIX K
CARS ST OR CARS HF SCORES OF PARTICIPANTS WITH AUTISM

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>CARS Score</th>
<th>CARS-2-ST Score</th>
<th>Severity Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>15-29</td>
<td>Minimal to No Symptoms of Autism Spectrum Disorder</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>22.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>28.5*</td>
<td>30-36.5</td>
<td>Mild-to-Moderate Symptoms of Autism Spectrum Disorder</td>
</tr>
<tr>
<td>7</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>38*</td>
<td>37 and higher</td>
<td>Severe Symptoms of Autism Spectrum Disorder</td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>24.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>22.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>28*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>31.5*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>28*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARS-2-HF Score</th>
<th>Severity Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-27.5</td>
<td>Minimal to No Symptoms of Autism Spectrum Disorder</td>
</tr>
<tr>
<td>28-33.5</td>
<td>Mild-to-Moderate Symptoms of Autism Spectrum Disorder</td>
</tr>
<tr>
<td>34 and higher</td>
<td>Severe Symptoms of Autism Spectrum Disorder</td>
</tr>
</tbody>
</table>

Note. *=indicates the CARS-2-HF was administered because the child was above age 6:0. Missing numbers indicate children with autism who did not meet qualification requirements.

Twelve out of thirteen children were receiving speech and language services at the time of the parent interview, with the remaining child previously receiving services. Therefore, scores represent behavior, communication, and social interaction skills post-treatment.
## APPENDIX L
### STORY COMPREHENSION RAW SCORES

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>iPad® with the Read-to-me Feature</th>
<th>iPad® Book Read by the PI</th>
<th>Traditional Paper Book</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1E</td>
<td>1R</td>
<td>2E</td>
</tr>
<tr>
<td>001</td>
<td>3</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>777</td>
<td>4</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>002</td>
<td>5</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>555</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>003</td>
<td>3</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>888</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>006</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>101</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>007</td>
<td>4</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>103</td>
<td>6</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>008</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>105</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>009</td>
<td>1</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>111</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>011</td>
<td>4</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>999</td>
<td>4</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>012</td>
<td>4</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>106</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>013</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>108</td>
<td>3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>015</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>107</td>
<td>6</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>016</td>
<td>5</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>104</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>020</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>444</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Total Points Possible</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

**Key:** The number in each column indicates level of question (Blank’s level 1 or 2). Next, the first letter indicates whether the question was E (expressive) or R (receptive). Shading indicates participant matching with the participant with ASD listed first.
### APPENDIX M

**PARTICIPANTS’ EXPERIENCE WITH THE iPAD® AND PETE THE CAT BOOKS**  
**PER PARENT REPORT**

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Experience with the iPad®</th>
<th>Exposure to Pete the Cat Books</th>
<th>Has used iPad® books</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>777</td>
<td>2&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>555</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>888</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>101</td>
<td>4&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>103</td>
<td>2&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>105</td>
<td>3&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
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</tr>
<tr>
<td>111</td>
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</tr>
<tr>
<td>11</td>
<td>3</td>
<td>1</td>
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</tr>
<tr>
<td>999</td>
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</tr>
<tr>
<td>12</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>106</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>2&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>108</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>107</td>
<td>3&lt;sup&gt;g&lt;/sup&gt;</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>104</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>444</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:** Participant numbers 1-20 indicate children with autism, and repeating participant numbers or those that begin in “10” are vocabulary-age matched peers.  
**Key:** Experience with iPad®: 0 = none, 1 = 1-6 months, 2 = 7 months-1 year, 3 = 1 year 1 month-2 years, 4 = 2 years 1 month to 3 years, 5 = 3 years, 1 month - 4 years, 6 = 4 years; Exposure to Pete the Cat Books: 0 = none, 1 = some; Has used iPad® books: 1 = yes, 0 = no.  
<sup>a</sup> Other tablet & smartphone,  
<sup>b</sup> Other tablet,  
<sup>c</sup> computer, tablet, & smartphone,  
<sup>d</sup> Surface tablet, mini tablet, & smartphone,  
<sup>e</sup> Leap Pad,  
<sup>f</sup>iPad® & iPhone®,  
<sup>g</sup> Kindle & Leap Pad
Fifteen typically developing preschoolers ages three to five were asked ten questions (by trained CSD graduate students) developed by the PI at *Levels of Abstraction 1 and 2* (Blank, et al., 2003) for each of the three paper-based books. Five questions required expressive responses and five questions required receptive responses in each book. Following the pilot study, some questions were modified and a scoring rubric for the dissertation study story comprehension questions was developed (see Appendices G, H, I). For example, after scoring responses to the expressive *Level 2* question: “What is happening in this picture?” for the *Pete the Cat: Too Cool for School* story, that question was asked on a different page during the dissertation study. The rationale for this change was that a different picture elicited a clearer, appropriate response. During the pilot study, this question was asked on a page in which Pete was “too hot”, but he was looking in the mirror. For the dissertation, this question was asked on the page where a cat was driving the bus. Similarly, the question “Where is the bread?” in the *Pete the Cat and the Bad Banana* story elicited both “stove” and “oven” as responses during the pilot study. “Oven” was the *fully acceptable* answer, earning 3 points and “stove” was considered an *acceptable* answer, earning 2 points (See Appendix D). Additionally, this question elicited a pointing (receptive) response rather than a word or phrase (expressive), which was the aim of the question. For the dissertation study, this question was changed to “What’s in the oven?” to encourage an expressive response.