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Literacy Development in Autism: Predicting Reading Comprehension  
Using AIMSweb Early Literacy Measures

A Thesis submitted in partial satisfaction  
of the requirements for the degree of

Master of Arts

in

Education

by

Erin Marie Knight

March 2014

Thesis Committee:

Dr. Jan Blacher, Chairperson  
Dr. Michael L. Vanderwood  
Dr. Cathleen A. Geraghty

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The Thesis of Erin Marie Knight is approved:

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Committee Chairperson

University of California, Riverside

## ABSTRACT OF THE THESIS

### Literacy Development in Autism: Predicting Reading Comprehension Using AIMSweb Early Literacy Measures

by

Erin Marie Knight

Master of Arts, Graduate Program in Education  
University of California, Riverside, March 2014  
Dr. Jan Blacher, Chairperson

The simple view of reading suggests that reading comprehension is the product of decoding skills and oral language comprehension. In line with this view, previous research suggests that there is a relationship between early literacy measures and comprehension measures in TD students; this area is more recently being examined in children with autism spectrum disorder (ASD). Furthermore, child characteristics, such as oral language skills, problem behaviors, IQ and social skills, effect the development of reading comprehension, especially in children with ASD who have specific deficits in these areas. Children between the ages of 4 and 7 ( $M = 5.13$  years) and their parents ( $N = 120$ ) were recruited from a larger longitudinal study and were assessed at three time points. Results suggest that components of early literacy develop out of concert in young children with ASD. Furthermore, while early literacy skills do predict reading comprehension in this sample ( $R^2 = .33$ ,  $F(1, 112) = 54.94$ ,  $p < .001$ ), oral language skills and IQ predict reading comprehension above and beyond these early literacy measures ( $R^2 = .42$ ,  $F(3, 108) = 26.06$ ,  $p < .001$ ). The reading development of children with ASD appears to be both similar and dissimilar to that of TD children.

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## Literacy Development in Autism: Predicting Reading Comprehension

### Using AIMSweb Early Literacy Measures

Children with an autism spectrum disorder (ASD) typically display a number of deficits that have an impact on their educational and social success in school. ASD symptoms exist on a continuum, which means that each child with ASD displays a unique combination of symptoms. However, there are core deficits associated with ASD, which include impairment in social communication and presentation of restricted and repetitive behaviors (5<sup>th</sup> ed.; *DSM-5*; American Psychiatric Association, 2013). Social communication deficits include impairment in social-emotional reciprocity; nonverbal behaviors, such as gesturing and facial expressions; delays in the development of language; and relationship building. Restricted and repetitive behaviors include stereotyped speech, such as echolalia and idiosyncratic phrases (e.g., scripted speech); adherence to routines, including ritualized nonverbal and verbal behavior; restricted interests; and abnormal reactivity to sensory stimuli. Many children with ASD display deficits outside of these core features, which can overlap with deficits in language disorders, intellectual disability (ID), attention-deficit/hyperactivity disorder (ADHD), social anxiety, and obsessive-compulsive disorder (OCD).

These concomitant deficits can further impact the overall functioning of children with ASD at school, beyond their social relationships. Some research has focused on how these deficits influence reading performance of children with ASD. For instance, it is theorized that poor oral language skills, such as those displayed by children with ASD who have poor communicative and social abilities, put children at risk for problems in

developing literacy (Bishop & Snowling, 2004). On the other hand, despite deficits in social or language domains, some children with ASD demonstrate hyperlexia, a reading profile characterized by average to above average decoding skills paired with poor reading comprehension skills (Aram, 1997; Gough & Tunmer, 1986; Grigorenko, Klin & Volkmar, 2003; Nation, 1999; Snowling & Frith, 1986). In fact, children with hyperlexia were said to have specific impairments in the cognitive, social and language domains (Aram, 1997), consistent with deficits displayed in ASD. The term hyperlexia was introduced in the 1960s by researchers who noted a subset of the population displaying these reading patterns, and that the children exhibiting this profile also demonstrated behaviors that were indicative of what the DSM-III would later call “infantile autism” (Silberberg & Silberberg, 1967). Consequently, one line of research has linked hyperlexia to ASD, as well as other developmental disabilities.

Accurately predicting this reading profile, or any reading profile, can be difficult because definitive research on reading in ASD is lacking. In general, reading comprehension develops throughout the elementary years, but difficulties begin to emerge around third grade when children should be developing a more diverse vocabulary (Rathvon, 2004). Research suggests that the early reading skills of decoding (the skills used to break down and sound out words) and fluency (the ability to recognize words quickly and accurately) can predict later reading ability, specifically comprehension (Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997; Fuchs, Fuchs, Hosp & Jenkins, 2001; Good, Simmons, & Kame’enui, 2001; Hudson, Pullen, Lane, & Torgesen, 2009).



Curriculum-based measurements (CBM) are tools that can be used to measure children's skills at one time and predict their later reading achievement based on meeting a cutoff score that indicates level of risk (Good, Simmons, & Kame'enui, 2001). Measures such as AIMSweb (Shinn & Shinn, 2002a; 2002b) and Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good & Kaminski, 2002) are extensions of CBM, and include timed probes for components of reading. They are individually administered and standardized measures originally developed by Deno and colleagues (Deno, 1985; Fuchs & Fuchs, 1999; Shinn, 1989) to measure skills from the curriculum in reading, math and writing. As a screening tool, CBM measures can be used to better target deficits so that children struggling with reading can improve their early literacy skills that will impact their later reading achievement. As a progress monitoring tool, CBM measures can be used on a continual basis to monitor the progress of children already receiving intervention in targeted areas. Considering that by definition, hyperlexic children develop reading comprehension skills that are not commensurate with their average to above average decoding skills, these tools may be flawed in predicting hyperlexic reading comprehension based on early literacy skills such as phonemic awareness, phonics and fluency. However, research is lacking in ASD in both the development of early literacy skills outside of hyperlexia, as well as the development of reading comprehension and how to predict it.

Additionally, research in reading comprehension in typically developing (TD) children and children with ASD has examined other features of a child's development that can impact and thus predict reading comprehension, including child characteristics

such as oral language, cognitive functioning, social skills and behavior problems. The first three of these characteristics can be deficient in children with ASD; behavior problems often appear in excess. Therefore, it is likely that the features of ASD impact both the development and prediction of reading comprehension.

### **Reading Development**

**The simple view of reading.** Perfetti, Landi, and Oakhill (2005) purport that comprehending spoken language is nearly equivalent to comprehending text. Additionally, reading comprehension skills are improved when lower level skills like decoding become automatic and no longer take up mental resources (Perfetti, 1985). The simple view of reading, which suggests that reading is the product of decoding skills as well as oral language comprehension, is the standard theoretical model for reading development and takes these points into account (Gough & Tunmer, 1986). This model proposes that a student's ability to decode words and to understand oral language should predict their later reading comprehension, the general outcome of reading (Gough & Tunmer, 1986). Once a child has gained adequate decoding skills and can identify words quickly with little cognitive exertion, he or she can begin to comprehend the meaning of the text and form ideas about its messages.

However, the relationship among all of these skills changes as a child ages (Hoover & Gough, 1990; Torgesen, Wagner, & Rashotte, 1997). Decoding skills are initially more highly correlated with reading comprehension when the child is first learning these skills, but oral language and cognitive skills become more predictive of reading comprehension as the child becomes less reliant on decoding skills and more

reliant upon fluency and their language skills. Therefore, oral language should only predict unique variance in reading comprehension when the child's decoding skills become automatic, a concept which incorporates features of both Perfetti's efficiency model (1985) and the simple view of reading (Gough & Tunmer, 1986).

A number of reading disabilities have been identified using the simple view of reading. Gough and Tunmer (1986) suggested that there are three types of reading disability that result from deficits in decoding and comprehension: (1) dyslexia, in which a child is a poor decoder and fails to learn to read despite normal cognitive functioning, (2) garden variety poor reading, in which a child has poor decoding skills paired with poor comprehension skills, and (3) hyperlexia, in which a child has above average decoding skills despite poor comprehension skills. Since the simple view asserts that reading is the product of decoding skills and listening comprehension, hyperlexic students are said to be able to read and comprehend text only as well as they can listen and communicate orally.

**Big five areas of reading.** The simple view of reading is more easily understood by breaking down reading into smaller components. According to the National Reading Panel (NRP; 2000), reading has five components: phonological awareness, phonics, fluency, vocabulary, and comprehension. Phonological awareness is the understanding that spoken words can be broken down into phonemes, which are the smallest unit of sounds; phonics is an understanding that the letters of the alphabet represent these sounds and can be blended together to make words; fluency is the ability to decode and recognize words quickly and with accuracy; vocabulary is the knowledge of words and

their meanings; and comprehension is understanding the message of a text. The first step in reading development is decoding, or breaking down and sounding out words, which is comprised of early literacy skills such as phonological awareness and phonics. Fluency develops when a child can automatically decode words and can read them with little cognitive effort (Juel, 1991). Comprehension involves understanding what was decoded or read. Children first learn to read (decode), and then read to learn (comprehend) (Catts, Hogan, & Adolf, 2005).

Phonological awareness is one of the first components of reading to develop. It is the understanding of the sound structure of language (Rathvon, 2004). This awareness is critical in developing other skills, such as phonics, because children must first understand that words can be broken up into smaller sounds before they can combine these sounds and read. Research has suggested that a child's phonological awareness skills are predictive of their later reading proficiency (Caravolas, Hulme, & Snowling, 2001; de Jong and van der Leij, 2002; Hulme et al., 2002; Scanlon & Vellutino, 1996; Wagner et al., 1997).

Phonics is the understanding that written letters represent sounds, or phonemes (Rathvon, 2004). The development of phonics skills is typically dependent on student readiness for school and direct phonics instruction (Foster & Miller, 2007). By the end of first grade, students who came to kindergarten with average or high pre-literacy skills achieved high decoding scores, while those who had below average literacy skills did not make up for the gap until third grade (Foster & Miller, 2007). These word-level reading skills are highly correlated with reading comprehension in TD children (Perfetti, 1985).

Typically, children who have displayed a mastery of decoding skills (i.e., phonological awareness and phonics) will proceed to develop fluency and then to master comprehension.

The development of reading fluency depends on the successful acquisition of early literacy skills, and poor reading fluency is often associated with reading disability (Lyon, 1996). Reading fluency is critical to reading comprehension because quick and accurate word reading frees up resources so that the reader can focus on comprehending the text (Nathan & Stanovich, 1991; Perfetti, 1985). Consequently, reading fluency is highly correlated with reading comprehension (Fuchs, Fuchs, & Maxwell, 1988; Markell & Deno, 1997).

Reading comprehension, the ultimate goal of reading, is the ability to understand the meaning of text (Rathvon, 2004). The NRP (2000) suggests that reading comprehension is a complex cognitive process that depends on vocabulary development. Vocabulary, or word knowledge, is a critical element of reading comprehension. The stronger a student's vocabulary and knowledge of the words they are reading, the easier it is to comprehend the text (NRP, 2000). While the development of these skills, culminating in reading comprehension, in TD children has been a topic of research for decades, the early development of these component literacy skills is not often addressed in children with ASD.

**Measuring the big five.** According to the simple view of reading, a child's decoding skills should predict his or her reading comprehension. This relationship has been investigated in typically developing children, specifically in the research on

response to intervention (RTI). RTI is a multi-tiered system that includes multiple levels of support to remediate early reading difficulties to prevent later reading disability. As mentioned above, AIMSweb and DIBELS are CBM tools that are used in schools implementing RTI to measure children's early reading skills, which can inform classroom instruction and supplemental interventions. These tools measure each of the big five areas of reading. They include measures of letter-naming fluency (LNF; DIBELS & AIMSweb), letter-sound fluency (LSF; AIMSweb), and first sound fluency (FSF; DIBELS), all of which are early measures of phonics; phoneme segmentation fluency, which measures phonological awareness (PSF; DIBELS and AIMSweb); nonsense word fluency, which measures phonics (NWF; DIBELS and AIMSweb); oral reading fluency which is a general outcome measure of all early literacy skills and fluency (ORF for DIBELS; R-CBM for AIMSweb); and a cloze reading test of reading comprehension (DAZE for DIBELS; MAZE for AIMSweb), in which students are asked to fill in blanks with a word.

CBM tools such as AIMSweb and DIBELS differ greatly from other measures of reading skills used in research in a number of ways. First, children are tested individually using probes for each measure, dependent on age. For instance, a child entering the first grade year might be tested with LNF, LSF, and PSF because this is the age when phonological awareness skills should be developed. The examiner provides the child with standardized instructions each time a probe is given. Children are given one minute for each probe, except DAZE and MAZE, for which they are given three minutes for each probe. They are given one probe at a time for all measures except ORF, for which they

are given three probes in order to obtain a median score. Measures are timed and require less time to complete than other standardized assessments of reading skills. These tools can be used to monitor change in skills over time. This is different from other measures used in research, such as the Woodcock-Johnson III Tests of Achievement (WJ-III ACH; Woodcock, McGrew, & Mather, 2001; 2007), in which most subtests are not timed. Additionally, these CBM measures are criterion-referenced, meaning any classifications that arise from the scores are in reference to how that child should be performing in order to reach a certain criterion in the future. Other tools used to measure reading skills are typically norm-referenced, meaning that resultant scores indicate a child's performance in reference to other children his or her age. While these criterion-referenced CBM measures are increasingly being used in schools, their use has not been examined in children with developmental delays, such as ASD.

### **Decoding Skills in ASD**

The unique nature of ASD and its continuum of symptoms has led to interest in reading development in children with ASD, since deficits in ASD are associated with difficulty with decoding and comprehension. Although research in decoding and reading comprehension skills in children with ASD has been largely inconclusive, some research has suggested that children with ASD have strong decoding skills (Mayes & Calhoun, 2003; Minshew, Goldstein, Taylor, & Siegel, 1994). This is despite potential deficits in areas that affect decoding, such as cognitive functioning and oral language. There is great variability in the intellectual capabilities of children with ASD; however, Mayes and Calhoun (2003) report that children at varying levels on the spectrum, even those below

normal limits (IQ < 80) were able to achieve decoding scores within a normal range. Not only have children on the spectrum displayed average decoding skills despite core deficits, but some research suggests that higher-functioning children with ASD typically score at or *above* the population mean for decoding (Huemer & Mann, 2010).

Beyond cognitive functioning, language impairment is a potential roadblock to the development of adequate decoding skills, since oral language skills impact decoding. For this reason, children with ASD and concomitant language impairment have been compared to children with language impairment only and to children with ASD with no concomitant language impairment (Lindgren et al., 2009). This is in an attempt to disentangle differences in the effects of language impairment (language impairment or no language impairment) versus diagnosis (ASD or no ASD). Children with ASD and language impairment performed better on a non-word reading task similar to NWF, a measure of phonics, than children with language impairment only (Lindgren et al., 2009). This would suggest that there is a component in ASD that protects these children against developing poor decoding skills; in fact, it could suggest that ASD helps to establish superior decoding skills.

Newman and colleagues similarly found that children with ASD and hyperlexia outperformed their peers with ASD on a non-word reading task, mimicking the results of Lindgren and colleagues (Newman et al., 2007). Results of their study also showed that children with ASD and hyperlexia performed just as well as the TD controls on tests of single word reading and better than children with ASD without hyperlexia. Consistent with the definition of hyperlexia, these children conversely scored lower on reading



comprehension. The results of this study suggest that children with ASD and hyperlexia have heightened decoding skills as compared to other children with ASD and without hyperlexia.

However, further research examining individual differences shows that there is greater variability in the development of decoding and other early literacy skills than these studies suggest (Davidson & Weismer, 2013; Nation, Clarke, Wright & Williams, 2006). Decoding skills in children with ASD might develop out of concert; for instance, children with ASD tend to demonstrate deficits in phonological awareness (Gabig, 2010; Heimann, Nelson, Tjus & Gillberg, 1995), despite average phonics skills (Nation et al., 2006) and above average letter naming (Lanter, Freeman, & Dove, 2012). There has been an effort in the literature to identify these factors and detail the variability in attainment of decoding skills.

Norbury and Nation (2011) replicated the study conducted by Lindgren and colleagues (2009) with modifications and found that children with ASD, with and without a language impairment, performed no differently on non-word phonics reading tasks than TD children, contradictory to the aforementioned previous findings where only the ASD children with language impairment performed as well as TD children. Furthermore, a meta-analysis on the literacy development of children with ASD suggested that the decoding skills of children with ASD were similar to TD children in the compiled studies (Brown, Oram-Cardy, & Johnson, 2013). Specifically, there was heterogeneity among children with ASD in these studies; there were children with average to above average decoding skills, as well as children whose decoding skills were

below average. These results indicate variability in the development of decoding skills in children with ASD, which resembles the development of these skills in TD children. However, different from TD reading development, some research also suggests that these early literacy skills develop out of concert in ASD (Davidson & Weismer, 2013; Nation et al., 2006). Overall, there is no consensus on the development of decoding skills in children with ASD.

### **Reading Comprehension**

Reading comprehension is the ultimate goal of reading (Cornoldi & Oakhill, 1996). Despite this, little research has focused on reading comprehension, its development, and how problems with reading comprehension develop (Snow, 2002), especially in children with ASD (Ricketts, 2011). However, what research does exist on reading comprehension in TD children informs research in children with ASD. While average reading comprehension can typically be predicted using prior success with decoding, deficits in reading comprehension are more difficult to predict. Poor decoding skills appear to have an impact on the development of reading comprehension, but other deficits may explain why reading comprehension fails when decoding skills are intact.

**Deficits in reading comprehension.** Research on deficits in reading comprehension beyond decoding skills in the TD literature, addressed here, has focused primarily on oral language skills, IQ, social skills and problem behaviors. Poor oral language skills have been connected to difficulties with later reading achievement (Bishop & Snowling, 2004; Nation, Clarke, Marshall, & Durand, 2004). Oral language is comprised of five components. These include phonology, or the sounds of words;

semantics, or the meaning; morphology, or the structure; syntax, or the structure of sentences; and pragmatics, or the use of language (Rathvon, 2004). Difficulties with any of these components of oral language affect the development of reading comprehension and later reading achievement (Bishop & Snowling, 2004).

Oral language comprehension has been examined in its relationship to reading comprehension in TD children (Bishop & Adams, 1990; Botting, Simkin, & Conti-Ramsden, 2006; Nation et al., 2006; Vellutino, Scanlon, & Tanzman, 1994). Vellutino, Scanlon, and Tanzman (1994) found that oral language comprehension was the best predictor of reading comprehension, except for younger, poor readers for whom decoding was the best predictor. TD children with identified language impairments are at a higher risk for later reading failure (Botting, Simkin, & Conti-Ramsden, 2006), and conversely, many children with identified reading comprehension deficits have co-occurring language deficits that are reminiscent of specific language impairment (SLI; Nation et al., 2006). Additionally, children with concomitant poor decoding and poor oral language tend to be at a higher risk for reading failure than children with deficits in one area (Bishop & Adams, 1990), which reflects the simple view of reading.

As with many deficits, IQ has been considered to have an impact on the development of reading comprehension, since reading comprehension is an involved cognitive process. However, it has not typically been shown to directly impact reading comprehension on its own; IQ may be such a strong predictor of reading comprehension because many measures of IQ require the use of oral language skills (Rathvon, 2004). The same skills that are required to comprehend language are required to perform well on

an IQ test. Reflecting this dependence of IQ on other skills, research shows that the effect of IQ on reading development typically depends on other factors. For instance, low cognitive functioning might heighten poor decoding; poor decoding skills might influence reading development more in a child with low cognitive functioning than in a child with high cognitive functioning (Bishop & Snowling, 2004); it is possible this relationship is true for skills other than decoding.

Malecki and Elliott (2002) built on social theories proposed by Bandura and Vygotsky to suggest that social behavior can predict general academic achievement, particularly in the area of reading. They found that social skills, as measured by the Social Skills Rating System-Teacher Rating Form (SSRS; Gresham & Elliot, 1990) in fall positively predicted overall achievement in spring. The authors found similar results when examining the impact of problem behaviors on reading achievement. Problem behaviors rated in the fall by teachers using the SSRS negatively predicted overall achievement in the spring. However, neither social skills nor problem behaviors in fall specifically predicted reading achievement in spring. Therefore, social skills and problem behaviors may impact academic achievement more indirectly.

**ASD characteristics and reading comprehension deficits.** Research on the typical development of reading comprehension and how deficits emerge is illuminating for the study of deficits in children with ASD. As mentioned above, poor oral language, poor social skills, behavior problems and low cognitive skills have all been linked to poor reading comprehension. While these deficits exist in clusters in the TD population, they tend to be central features of ASD, putting these children at greater risk for difficulties in

reading comprehension. Therefore, features of ASD have been examined as contributors to deficits in reading comprehension.

Children with ASD commonly display delays and deficits in oral language (Lindgren et al., 2009; Nation et al., 2006). Since non-autistic children with language impairments display a higher risk of poor reading comprehension (Botting et al., 2006), it follows that children with ASD with language impairment would display a similar tendency. Nation et al. (2006) reported a large correlation between reading comprehension skills and receptive oral language skills in their sample of adolescents with ASD ( $r = .72, p < .01$ ). The authors found that poor comprehenders had lower receptive oral language skills, while average comprehenders had higher receptive oral language skills. Earlier research conducted by Snowling and Frith (1986) also examined reading comprehension as a function of oral language skills. Similar to Nation and colleagues, Snowling and Frith reported that children with ASD and high verbal ability had reading comprehension abilities commensurate with their decoding skills, while children with low verbal ability showed impaired reading comprehension not commensurate with their decoding skills. Additionally, in one of the only studies of reading comprehension in young children with ASD, Davidson and Weismer (2013) found that nonverbal intelligence and expressive oral language (rather than receptive language) were predictive of later reading ability. However, they did not include a measure of decoding skills in their analyses.

Some research has aimed to examine differences in reading as a function of oral language. Norbury and Nation (2011) conducted a study that investigated and compared

the effects of oral language skills on three different measures of reading comprehension in three groups of adolescents: those with ASD and language impairment (ALI), those with ASD and no language impairment (ALN), and TD adolescents. Regarding differences in reading comprehension, ASD adolescents with language impairment were generally poorer at comprehending connected text than adolescents in other groups. Within the whole sample, however, word-level reading accounted for anywhere between 6 to 37% of the variance in reading comprehension and oral language skills accounted for between 15 to 31% of the variance in outcome, indicating that oral language does predict unique variance in the sample above and beyond decoding skills (Norbury & Nation, 2011). Additionally, for one comprehension measure, ASD status uniquely predicted 10.7% of the variance in the outcome. Their results indicated that oral language skills predicted reading comprehension, in their sample of TD adolescents and adolescents with ASD, above and beyond word-level reading skills. Therefore, there is a clear connection between oral language development and poor reading comprehension in TD adolescents and adolescents with ASD, alike, and variation in oral language seems to be related to variation in reading comprehension.

Similar to analyses conducted by Norbury and Nation (2011), Ricketts, Jones, Happé, and Charman (2013) looked at multiple features of ASD and examined the ability of word recognition, oral language, and social functioning to predict unique variance in reading comprehension in their heterogeneous sample of adolescents ( $M = 15.6$  years,  $SD = 6$  months) with varying levels of ASD impairment. Their results suggest that both word recognition and oral language comprehension accounted for a significant amount of

variance in reading comprehension for this sample of adolescents; additionally, social skills (as measured by social-communication scores on the ADOS) and social cognition (as measured by two researcher-developed measures previously used) also accounted for a significant amount of variance. This indicates that the relationship between decoding skills and reading comprehension might not only be mediated by oral language, but by other features of ASD, as well.

Social difficulties are linked to oral language development, particularly in children with ASD. Some of the earliest predictors of later gains in language are social factors, including joint attention (Charman et al., 2003) and following of gaze (McDuffie, Yoder, & Stone, 2006). Although variability in language development is not entirely explained by social factors (Lindgren et al., 2009), there seems to be an indirect relationship between social skills and reading due to the established relationship between oral language and reading comprehension. Estes and colleagues reported that better social skills in children with ASD, measured by the SSRS, were associated with higher academic achievement, specifically in word reading (Estes, Rivera, Bryan, Cali, & Dawson, 2011). This shows that there may be some link between social skills and reading achievement, stronger than what is seen in TD children (Malecki & Elliott, 2002).

Problem behaviors are frequently found to be more prevalent in children with ASD, particularly those found to be associated with internalizing symptoms (Bellini, 2004; Kim, Szatmari, Bryson, Streiner, & Wilson, 2000), externalizing symptoms (Tonge, Brereton, Gray, & Einfeld, 1999), Attention-Deficit/Hyperactive Disorder (ADHD; Mayes, Calhoun, Mayes, & Molitoris, 2012), and restricted and repetitive

behaviors (5<sup>th</sup> ed.; *DSM-5*; American Psychiatric Association, 2013). These problem behaviors inevitably have an impact on academics; however, their impact on reading achievement in ASD has not been studied directly. While problem behaviors have not been found to specifically predict negative outcomes in reading comprehension, these behaviors may affect performance on measures of reading.

Cognitive deficits are existent in some children with ASD, specifically those who are lower functioning. IQ tests have often been considered a proxy for oral language since performance on many of these measures is reliant upon a child's oral language ability. In relation to reading comprehension, cognitive deficits in ASD may lead to difficulty with self-monitoring (O'Connor & Klein, 2004). Other cognitive factors, such as weak central coherence, or the ability to understand context, have been posited as potential contributors to poor comprehension skills because they can lead to difficulties in integrating text (Happé & Frith, 2006). In applying these theories, Davidson & Weismer (2013) determined that nonverbal intelligence predicted unique variance in reading comprehension, in addition to expressive oral language, for young children with ASD, suggesting that cognitive functioning might also play a role in the development of adequate reading comprehension skills.

ASD symptom severity has been examined in an effort to explain differences in the development of reading comprehension. Differences in reading comprehension have been found between different diagnostic groups. Huemer and Mann (2010) used varying symptom severities in accordance with DSM-IV diagnoses of pervasive developmental disorder-not otherwise specified (PDD-NOS), Asperger's syndrome, and autism to



examine differences in reading comprehension. In addition to their aforementioned finding that children with ASD scored at or above the population mean for decoding skills, the authors found that in the area of comprehension, children with Asperger's scored above the population mean, while those with autism or PDD-NOS scored below the population mean. Therefore, the Asperger's group showed typical reading development, meaning that reading comprehension skills were commensurate with decoding skills. The PDD-NOS and the autism groups had a similar reading profile reflective of hyperlexia: average or above average decoding skills and poor comprehension skills. Norbury & Nation (2011) also suggested that diagnostic status might have an impact on reading comprehension, as status predicted an additional 10.7% of the variance in one of their reading comprehension outcome measures.

Additionally, limited reading comprehension skills despite adequate cognitive functioning have been linked to autism symptom severity. Jones et al. (2009) provided preliminary support for this through correlational analyses that suggest that reading comprehension that falls below IQ (which was how the authors defined a reading comprehension deficit) is correlated with increasing deficits in social and communication domains, suggesting that increasing deficits in reading comprehension coincide with increasing deficits associated with ASD. Davidson & Weismer (2013) similarly found that autism symptom severity on the ADOS was correlated with reading skills. Therefore, there appears to be some relationship between reading performance and autism symptom severity, rather than just presentation of autistic-related deficits.

## **Predicting Reading Comprehension**

Research has established that the decoding skills of a TD child can predict later reading ability, specifically in comprehension. CBMs are tools that measure these early skills at one time and predict their later reading achievement based on a criterion. As mentioned previously, the accuracy of their predictions of reading comprehension in children that develop hyperlexia might be poor due to the limited relationship between decoding skills and reading comprehension, especially since there is no established method of determining which children will develop the hyperlexic reading profile. Additionally, characteristics of ASD could present difficulties in administration of these tools.

**Using CBM to predict reading comprehension.** In an RTI framework, screening for early literacy difficulties is a critical part of the preventative model (Jenkins, Hudson, & Johnson, 2007). DIBELS and AIMSweb are valid and reliable measures of early literacy skills that predict performance on state tests (Good, Simmons, & Kame'enui, 2001; Kaminski & Good, 1996). In order for these literacy measures to have utility in predicting later reading ability, there should be a relationship between performance on these measures and later performance on standardized measures of reading achievement. In addition to studies of the validity of DIBELS and AIMSweb, several studies have demonstrated the correlation between performance on AIMSweb and performance on standardized measures of reading comprehension, but only in TD children (Burke, Hagan-Burke, Kwok, & Parker, 2009; Kim, Petscher, Schatschneider, & Foorman, 2010; Riedel, 2007).

Burke, Hagan-Burke, Kwok, and Parker (2009) conducted multiple analyses to examine the predictive ability of DIBELS kindergarten tests of early literacy on later comprehension. Burke and colleagues used four DIBELS assessments to predict performance on various outcome measures, including the passage comprehension subtest of the *Woodcock Reading Mastery Test-Revised* (WRMT-R; Woodcock, 1987). Results of the correlations showed that NWF was the early literacy measure that was correlated most highly with passage comprehension. ORF, a general outcome measure of fluency, was found to explain much of the variance in passage comprehension ( $R^2 = .48$ ).

Riedel (2007) studied the predictive validity of DIBELS subtests on overall reading ability, and also examined this relationship with an emphasis on comprehension, as measured by the Group Reading Assessment and Diagnostic Evaluation (GRA+DE; Williams, 2001). Riedel first conducted a ROC analysis on beginning-, middle-, and end-of-first grade DIBELS scores ability to predict the end of first-grade comprehension of TD children. The results suggested that ORF was the best predictor at the middle and end of the year, followed by NWF. The author also conducted a stepwise regression, which indicated that a combination of ORF and NWF was better than ORF alone in predicting end of first grade comprehension on the GRA+DE. Interestingly, this suggests that decoding skills helped predict reading comprehension better than the general outcome measure alone. Riedel also examined the differences between children for whom the DIBELS assessments were a significant predictor of GRA+DE comprehension, and those for whom it was not. Consistent with research on vocabulary and reading comprehension, the author found that while the groups performed similarly on ORF, the group with poor

comprehension scored much lower on the vocabulary subtest of the GRA+DE than did the group with average comprehension. These results support the assertion that vocabulary and verbal ability might aid in distinguishing between poor comprehenders and average comprehenders when assessment of decoding skills fails to form adequate predictions.

**Decoding skills and reading comprehension.** While there are clear overlaps in the study of child characteristics and reading comprehension in the TD and ASD literature, discrepancies have been found in the correlation between reading accuracy (proportion of words read correctly to total words attempted) and reading comprehension in TD children versus children with ASD. Nation et al. (2006) found a moderate correlation, according to Cohen (1988), between accuracy and comprehension in students with ASD ( $r = .57, p < .05$ ), despite average reading accuracy. While the correlation is clear, it is lower than the large correlation found in a normative sample ( $r = .87, p < .01$ ) (Nation & Snowling, 1997). Therefore, while child characteristics such as oral language seem to impact reading comprehension in both TD children and children with ASD, decoding skills appear to have a different relationship with reading comprehension in these two groups. This indicates that there may be different trajectories in the reading development of students with ASD. In fact, reading accuracy and reading comprehension, although typically highly correlated (Chard, Vaughn, & Tyler, 2002), are often dissociated in certain populations (Botting et al., 2006). The differences in trajectories calls for a deeper look into the measurement of decoding skills and into preventative measures taken to avoid reading difficulties in later grades.

**Child characteristics and reading comprehension.** Due to the relationship between child characteristics and reading comprehension, child characteristics should predict reading comprehension skills. Research using TD children and adolescents has examined the ability of child characteristics, specifically oral language as per the simple view of reading, to predict unique variance in reading achievement. When reading comprehension is the outcome, oral language explains unique variance in young children, indicating that oral language begins to have an impact on the development of later reading comprehension at an early age (Bishop & Adams, 1990; Catts, 1993; Tomblin, Zhang, Buckwalter, & Catts, 2000). Additionally, IQ tends to alter the relationship between language and comprehension; studies that include a wide variety of IQs have shown that oral language skills predict later reading ability, while studies that only recruit children and adolescents with average to above average IQs do not typically find differences in oral language between poor readers versus good readers (Rathvon, 2004).

**Decoding skills versus child characteristics.** While child characteristics may be important in the development of reading skills in both TD and ASD children, word identification and phonemic decoding skills are better able to predict reading comprehension in TD children than IQ or oral language ability (Foorman et al., 1997; Gough & Tunmer, 1986). In fact, decoding skills in first grade can account for up to 80% of the variance in reading comprehension (Foorman et al., 1997). However, IQ and oral language ability become better predictors as children age since decoding becomes more automatic (Hoover & Gough, 1990; Storch & Whitehurst, 2002; Torgesen, Wagner, Rashotte, Alexander & Conway, 1997). Conversely, for poor readers, decoding skills

remain the best predictor of later comprehension (Rathvon, 2004), and the best predictor in the early elementary years for TD children. Much of the literacy research in ASD is conducted with older children, whose oral language should be more highly correlated with reading comprehension in light of typical reading development. A child's literacy development and the relationship between his or her early literacy skills and reading comprehension are of the most interest when they are first beginning to read.

### **A Model for Predicting Comprehension in Children with ASD**

While the proposed theoretical framework for the development of reading comprehension in TD children is the simple view of reading, the study of the relationship between decoding skills and reading comprehension is limited in children with ASD. Although some research in ASD incorporates decoding skills as predictors of reading comprehension, most research has predominantly focused on within-child characteristics that are typically seen as deficient in autistic children, such as cognitive level, social skills deficits and problem behaviors (Estes et al., 2011; Mayes & Calhoun, 2003), with a particularly strong focus on oral language skills (Nation et al., 2006; Nation & Norbury, 2005; Norbury & Nation, 2011; Ricketts, 2011). Therefore, there is little research that examines the interaction between oral language skills, and other child characteristics, and decoding skills in the development of reading comprehension skills in young children with ASD.

### **Limitations in the Research**

The study of the relationship between decoding skills and reading comprehension in children with ASD has been limited in a number of ways. First, the measures that have

been used are typically individualized and standardized full battery assessments of reading, and while they measure the same skills as CBM measures, the same time restrictions are not applied which allows for the possibility of needing more behavior management. Children with ASD may have difficulties with test taking due to disruptive behaviors associated with ASD, as well as lack of attention to and motivation to complete tasks without reward (Koegel, Koegel & Smith, 1997; Koegel & Mentis, 1985). The limitations associated with timed measures, such as not pausing the timer once it is started, can produce challenges if the child begins to demonstrate disruptive behaviors, such as self-stimulation or task avoidance. Conversely, AIMSweb measures require the child to be seated for less time, which may be beneficial in relation to motivational and attention-related issues. The variability in the decoding skills of children with ASD and the potential difficulties with accurately measuring these skills due to associated deficits make the measurement of decoding an area of interest in research. More research is required to understand the variability of decoding skills of children with ASD as measured with different instruments, especially CBM tools that are frequently used in schools to inform instruction and intervention.

Second, although early literacy skills develop beginning around kindergarten and first grade, the available studies in the literature focus on reading achievement in the later elementary school years. Rather than using early literacy to indicate later comprehension, these studies have focused on studying decoding skills years after they have developed (i.e., when the students are between the ages of 10 and 16). This can be problematic for a number of reasons; first, at this point, reading comprehension has already developed,

rendering a study of skills development difficult to achieve. Furthermore, at older ages, child characteristics such as oral language and IQ are more highly correlated with reading comprehension in TD children; therefore, it is not surprising that the same relationship may be displayed for a child with ASD. However, the interaction among child characteristics, decoding skills and reading comprehension has not been examined in younger children with ASD (i.e., ages 4 to 7). By studying literacy development in ASD at an earlier age, we can determine if differences in development emerge early on, and whether child characteristics in younger children with ASD play a bigger role in reading comprehension than what has been reported for TD children.

Third, the participants in these studies have largely been high functioning, with the notable exception of a handful of studies (Ricketts et al., 2013). In order to examine the impact of various deficits on the presentation of reading comprehension skills, it is beneficial to include some variation, specifically in terms of IQ and language ability. Rathvon (2004) purported that studies using TD children that included a wide range of levels of functioning were better able to disentangle differences. By referencing a sample of children with varying abilities, the impact of these abilities on reading comprehension may become clearer.

Finally, while some researchers have considered the impact of oral language on the relationship between decoding skills and reading comprehension in children with ASD (Nation et al., 2006; Norbury & Nation, 2011; Ricketts et al., 2013; Snowling & Frith, 1986), only a couple (Davidson & Weismer, 2013; Ricketts et al., 2013) have considered other features in the wide range of deficits associated with autism that may



impact the development of poor reading comprehension. Additionally, these studies have focused on a narrow range of tools to measure these skills; the current study utilizes multiple valid and reliable measures to provide a better estimate of these skills. The original definitions of hyperlexia, and even recent conceptualizations, have described hyperlexia as occurring in tandem with deficits in social, cognitive, and language domains (Silberberg & Silberberg, 1967; Aram, 1997). It is important to understand how deficits in these areas might influence the expression of a hyperlexic profile in samples of children with ASD.

### **Current Study**

The current study aims to address gaps in the literature regarding assessment of early literacy skills and their relationship to later reading skills in children with ASD. While this has recently been an area of research in TD children, it remains largely unexplored in children on the spectrum. The goals of this study are to provide empirical support for the use of AIMSweb and other criterion-referenced CBM tools with children with developmental delays, as well as to examine the impact of decoding skills and child characteristics (at the beginning of the school year) on the development of reading comprehension (at the end of the school year) in a group of young children with ASD.

This study aims to address the following questions: (1) is there a difference between a sample of young children with ASD and national norms on AIMSweb benchmark measures of decoding skills? (2) What is the relationship between reading accuracy (calculated using performance on R-CBM) and reading comprehension? (3) What is the relationship between performance on AIMSweb measures and child

characteristics associated with ASD? What is the relationship between performance on AIMSweb and performance on WJ-III measures of decoding? (4) To what extent do AIMSweb literacy measures predict performance on standardized measures of reading comprehension for students with ASD? (5) To what extent do these child characteristics (e.g., oral language ability, IQ, social skills, problem behaviors) predict reading comprehension above and beyond literacy measures? Is this relationship similar in poor decoders and average decoders? (6) Is there a difference between poor comprehenders (defined as children who have a standard score less than or equal to 85 on a measure of reading comprehension) and average comprehenders (defined as children who have a standard score of more than 85) on measures of child characteristics, decoding skills, and fluency?

## **Methods**

### **Participants**

Children and parents participants were recruited from a longitudinal study conducted at sites in southern California (primarily from Riverside and Los Angeles Counties) and Boston, Massachusetts investigating the successful transition to school of children with ASD. Children were recruited from public and private schools, programs for children with ASD, and service providers in southern California and the greater Boston area. Participants were recruited in two waves, one beginning in summer 2011 and the second beginning in summer 2012.

The children recruited were between pre-kindergarten and second grade age, with a mean age of 5.13 years at the time of recruitment ( $SD = 1.0$  years). Consistent with the

ASD population, 83.1% of the sample recruited was male. The majority of the participants were white (71.1%), followed by Hispanic (14.8%), Asian (7.4%) and African-American (5.9%).

**Eligibility.** There were four inclusion criteria in order for children to be included in the study. First, the child's chronological age must have been between the ages of 4 years and 7 years, 3 months at the time of enrollment. The study focused on the transitional period into early elementary school, namely, pre-school through early second grade, which is a crucial period for reading skill development. Second, an outside diagnosis of (or suspicion of) an autism spectrum disorder (ASD) was required, including Pervasive Developmental Disorder not otherwise specified (PDD-NOS), Asperger's syndrome, high-functioning autism, and autism, now collectively referred to as autism spectrum disorder (ASD). All diagnoses were confirmed through the use of gold standard assessments and children without an outside diagnosis were further assessed to verify the classification. Third, an IQ above 50 was required to ensure that the child would be able to participate in the activities involved in the study. Similarly, children in the study were required to have a level of language that would allow them to participate in the study activities (e.g., at least single words).

**Sample size.** Recruitment was ongoing during the study, and participants continued to enroll after the study began. By the end of recruitment for both waves, 136 children were deemed eligible for participation. Cases were included in this study only if the child had completed both a first and a second visit (which was when the outcome data was collected), leaving a slightly smaller sample ( $N=120$ ), with an attrition rate of

11.76%. Participant characteristics for the children included in this study are provided in Table 1. The means of the group retained for the study and the group that dropped out of the study were compared to ensure there were no differences based on attrition. The groups were no different in their age, sex, household income, oral language skills, IQ, social skills, problem behaviors, decoding skills, fluency, or reading comprehension.

### **Procedures**

This study utilizes a descriptive, correlational design examining the relationships among decoding skills, fluency, reading comprehension, and child characteristics in a sample of children with ASD. It is part of a longitudinal study and therefore includes data from multiple time points.

**Assessment procedures.** Participants and their parents were asked to come to an assessment center in Riverside (UCR) or Los Angeles (The Help Group, Sherman Oaks), California or in Boston, Massachusetts (UMass-Boston). Participants' eligibility was assessed first, and reading development was assessed over two visits: one in the beginning of the school year (fall) and one at the end of the school year (spring). One examiner assessed the child participant while another examiner interviewed the parent and went over the rating scales. At the end of the visit, the participant and his or her parent were reunited for a joint task. Participants and their parents were reimbursed at each visit for their participation in the study.

**Overview of visits.** The eligibility visit took place either in the summer before the school year (in 2011 or 2012) or in the very early fall of the school year (in 2011 or 2012). The first visit took place in the fall of the school year, 2011 or 2012 (i.e., at the

beginning of pre-kindergarten, kindergarten, first grade, or second grade), and the second visit took place in the spring of that same school year, 2012 or 2013 (i.e., at the end of their pre-kindergarten, kindergarten, first grade or second grade year).

The eligibility visit served as entrance into the study. Children with or without outside ASD diagnoses were assessed with the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavor, & Risi, 2008) to verify that they exhibited behaviors consistent with ASD. For cases where there was no previous diagnosis, parents also completed the Autism Diagnostic Interview – Revised (ADI-R; Rutter, LeCouteur, & Lord, 2003), with an assessor. All parents of children enrolled in the study filled out a Child Communication Checklist-2 (CCC-2; Bishop, 2006) on their child’s communication during the eligibility visit. In addition to participating in the ADOS assessment, children were given an abbreviated Wechsler Preschool and Primary Scales of Intelligence-III (WPPSI-III; Wechsler, 2002). Children that scored within the ASD range on the ADOS and received a score above 50 on the WPPSI-III were accepted into the study. As mentioned above, 136 participants were determined eligible after this visit.

After this visit, 120 participants continued on to the first visit (Time 1). During this visit, taking place at the beginning of the school year, participants completed an abbreviated version of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 2008) in order to gain an estimate of their oral language skills. Their early literacy skills were assessed with AIMSweb measures. Participants in preschool were assessed with LNF; those in kindergarten were assessed with LNF and LSF; those in first grade were assessed with LNF, LSF, PSF, and NWF; and those in second grade

were assessed with R-CBM. Three subtests of the WJ-III were given to participants, including Letter-Word Identification, Word Attack, and Reading Fluency. Parents rated their child's behavior using the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000; 2001) and their child's social skills using the Social Skills Improvement System (SSIS; Gresham & Elliott, 2008) during this visit.

During the second visit (Time 2), taking place at the end of the school year, children were assessed using the WJ-III. All participants were given the same three subtests of the WJ-III (above), as well as the Passage Comprehension subtest (the outcome measure) for this visit.

## **Measures**

Four measures were administered at the eligibility visit, and five measures were administered at two time-points, as indicated below.

**Eligibility: ADOS and ADI-R.** Participants came in for an eligibility visit in which they were assessed using the gold standard in ASD assessment, the ADOS (Lord, Rutter, DiLavor, & Risi, 2008), to either verify their outside diagnosis of ASD or provide an initial assessment indicating behaviors on the autism spectrum. The ADOS is a standardized, play-based interview and observation of child behavior in situations that elicit autistic tendencies. There are four modules that are used dependent on the child's verbal ability. The observation produces scores in four domains: Social Interaction, Communication, Stereotyped Behaviors and Restricted Interests, and Play. Of these domains, only two, Social Interaction and Communication, are included in the algorithm, which produces classifications of autism, autism spectrum, or not on the spectrum.

Children in this study were administered Module 1, Module 2, or Module 3 of the ADOS, dependent on their verbal ability. The ADOS has established reliability and validity from research on a sample of children with a diagnosis of autism (Lord et al., 2008). It has high sensitivity (upper 90%) and specificity (upper 80% to lower 90%) in discriminating between children with ASD and children without a spectrum disorder. The test-retest reliability is stable, especially for the Social Interaction and Communication domains. The internal consistency coefficients range from .47 to .94; the lowest values reported are from the Stereotyped Behaviors and Restricted Interests domain in Module 3, which is not included in the final algorithm.

Some children were further assessed using the Autism Diagnostic Interview-Revised (ADI-R; Rutter, LeCouteur, & Lord, 2003), a 93-item parent interview. The ADI-R produces scores in three domains: Language/Communication, Reciprocal Social Interactions, and Restricted, Repetitive and Stereotyped Behaviors and Interests. The ADI-R has very high test-retest reliability with coefficients ranging from .93 to .97. In the most recent study of inter-rater reliability (Chakrabarti & Fombonne, 2001), intraclass correlation coefficients were high (.86 for the total score). The ADI-R manual reports high diagnostic validity, with the validity being highest for children above 20 months.

**Eligibility: WPPSI-III.** Children's IQ was measured using the Wechsler Preschool and Primary Scales of Intelligence-III (WPPSI-III; Wechsler, 2002). The WPPSI-III, composed of 14 subtests, is a test of cognitive skills that was designed to follow Cattell-Horn-Carroll (CHC) theory, the most empirically validated theory of cognitive functioning. It is intended for use with children between the ages of 2:6 and

7:3. The full form of the WPPSI-III has internal consistency reliability coefficients ranging from .83 to .95, as well as high validity. For the purposes of this study, an abbreviated WPPSI-III was administered, using the block design, vocabulary and matrix reasoning subscales. Although abbreviated, the three-subtest version of the WPPSI-III has established reliability ( $r = .95$ ) and high predictive validity ( $r = .95$ ) in its estimation of cognitive skills (Sattler & Dumont, 2004).

**Eligibility: Child Communication Checklist – 2 (CCC-2).** The children's language skills were preliminarily measured using parent report on the Child Communication Checklist – 2 (CCC-2; Bishop, 2006). The CCC-2 measures skills in two domains: Language and Pragmatics. The CCC-2 has strong test-retest reliability with reliability coefficients ranging from .86 to .96, and internal consistency for the composite score, with reliability coefficients ranging from .94 to .96 for different age groups. The CCC-2 has adequate diagnostic validity, as evidenced by high sensitivity and specificity. The CCC-2 was best able to identify children with ASD (89%) and those who do not have ASD (97%) (Bishop, 2006).

**Comprehensive Assessment of Spoken Language (CASL).** Oral language was also measured using child performance on the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 2008) at Time 1. The Syntax Construction and Pragmatic Judgment subtests were used from the CASL. These subtests have adequate internal consistency, with coefficients ranging from .73 to .88 for Syntax Construction across age groups, and .77 to .92 for Pragmatic Judgment. Test-retest reliability was adequate for these subtests (.79 for Syntax Construction and .73 for Pragmatic



Judgment). Content validity was supported through research on disordered language. The criterion validity is high, as demonstrated by correlations with other measures of oral language, including the Peabody Picture Vocabulary Test – Third Edition (PPVT-III) with coefficients for the three subtests ranging from .45 to .66, and the Expressive Vocabulary Test (EVT), with coefficients for the three subtests all at .64. For the purposes of these analyses, the standards scores for these two subtests were added together and then divided by two to create a distribution around a mean of 100.

**Social Skills Improvement System (SSIS).** Social skills were measured by parent report on the Social Skills Improvement System (SSIS; Gresham & Elliott, 2008) at Time 1. The SSIS is a measure of social skills that provides overall estimates of major scales, including social skills, problem behaviors, and academic competence (Gresham & Elliott, 2008). The social skills scale was used in this study. This scale is composed of subscale estimates of social behaviors, including communication, cooperation, assertion, responsibility, empathy, engagement, and self-control. Parents were asked to rate specific behaviors exhibited by the child or adolescent on a 4-point scale based on frequency ratings from “never” (or “0”) to “almost always” (or “4”).

Median alpha levels for the major scales range from the mid to upper .90s. The test-retest reliability coefficient for the social skills scale is .84. The internal consistency reliability is high for the social skills subscales, with coefficients ranging from .74 to .96 across age groups. Reports of the validity of the measure include high correlations with other measures of social skills, including the Behavior Assessment System for Children

(2<sup>nd</sup> ed.; BASC-2, Reynolds & Kamphaus, 2004), with a coefficient of .67 for the BASC-2 Social Skills scale.

**Social Responsiveness Scale (SRS).** Autism symptom severity was examined with the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005). The SRS is a 65-item parent questionnaire that assesses behavior and communication associated with ASD. The SRS yields different scores for five subscales; the “Autistic Mannerisms” subscale will be used for this study. The reliability coefficients for the total score range from .93 to .97 across parent and teacher ratings. Additionally, it has demonstrated criterion validity with the ADI-R, with correlations between .52 and .79.

**Child Behavior Checklist (CBCL).** Behavior problems were measured using parent report on the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000; 2001) at Time 1. Raters were asked to complete the items describing their child’s functioning on a three point Likert scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true). Higher scores on subscales indicate greater levels of problematic behaviors. Depending on the child’s age, parents were either administered the CBCL for ages 1.5 to 5, or for ages 6 to 18. The CBCL for ages 1.5 to 5 contains 103 items. For the purposes of this study, the internalizing problem behaviors, externalizing problem behaviors, and total problems scales were used. Its test-retest reliability for the scales being used (internalizing behavior problems, externalizing behavior problems, and total problems) yielded reliability coefficients of .90, .87, and .90, respectively. Correlations between parent and teacher reports were .59 for internalizing behavior problems, .67 for externalizing behavior problems, and .65 for total problems. There is

evidence of discriminative, convergent and predictive validity. It is correlated with the Richman Behavior Checklist for children (.56 to .77), and therefore demonstrates adequate construct validity.

The CBCL for ages 6 to 18 contains 140 items (CBCL; Achenbach & Rescorla, 2001). As with the 1.5 to 5 scale, for the purposes of this study, the internalizing problem behaviors, externalizing problem behaviors, and total problems scales were used. Its test-retest reliability for the scales being used (internalizing behavior problems, externalizing behavior problems, and total problems) yielded reliability coefficients of .91, .92, and .94, respectively. Correlations between parent and teacher ratings were .72 for internalizing behavior problems, .85 for externalizing behavior problems, and .80 for total problems. Again, this scale shows evidence of discriminative, concurrent, convergent, and predictive validity. This scale demonstrates construct validity as it is correlated with the BASC-2 scale as rated by a parent for internalizing behavior problems (.80 to .83), externalizing behavior problems (.85 to .88), and total problems (.85 to .89).

**AIMSweb.** At Time 1, participants' early literacy skills were assessed based on their age, in accordance with suggestions given by AIMSweb (Shinn & Shinn, 2002a; 2002b). AIMSweb tools are timed, individually administered measures that provide curriculum-based estimates of a child's early literacy skills and reading skills.

AIMSweb tools used included letter naming fluency (LNF), letter sound fluency (LSF), phoneme segmentation fluency (PSF), nonsense word fluency (NWF), and reading curriculum-based measurement (R-CBM). LNF is a measure of a student's ability to recognize and label letters and requires the child to label as many letters as they can in

one minute. LSF is a measure of the child's ability to recognize letters and provide the examiner with the sound they make. It requires the child to provide the sounds of as many letters as he or she can in one minute. PSF is a phonological awareness measure that measures a child's ability to recognize individual sounds in words. The child is given words by the examiner and is asked to provide the examiner with all of the sounds in the word. For instance, if the examiner says, "cat," the child would respond with "/c/ /a/ /t/." The child is asked to provide as many sounds as they can in one minute. NWF is a phonics test that measures a child's ability to decode words that follow English word structure but do not exist in the language. The child is given a page of nonsense words such as "boj" and "tiff" and is asked to read them to the examiner and continues to read as many nonsense words as he or she can in one minute. This measure results in two scores: number of whole words read (for the child who is able to decode the word, blend the sounds, and read the word fluently), and number of correct letter sounds (for the child who is able to provide letter sounds but has difficulty blending them into a whole word). R-CBM is a general outcome measure of all of these skills, culminating in the child's overall fluency. The child is asked to read three passages and is given one minute for each passage to read as many words as he or she can. The median words read correctly and the median words read incorrectly are collected for the three passages. The reading accuracy of the child can be calculated by dividing the median words correct by the median total words read.

AIMSweb R-CBM passages' reliability coefficients are .90 and above across various reliability estimates, including test-retest, inter-rater, and split-half reliability

(Pearson, 2012). AIMSweb R-CBM passages are also correlated moderately with future reading achievement, such as state test scores, indicating adequate criterion validity (Pearson, 2012). Goffreda and DiPerna (2010) conducted a review of evidence for reliability and validity of similar CBM measures (DIBELS). They found that LNF had high test-retest reliability coefficients between .83 and .93, as well sufficient predictive validity between .30 and .57. PSF had high test-retest reliability (.88) and moderate convergent ( $Mdn = .33$ ) and predictive ( $Mdn = .38$ ), as well as concurrent validity with 22 other literacy measures. NWF had high test-retest reliability coefficients (.87 to .92), and moderate to high concurrent validity ( $Mdn = .58$ ) and predictive validity ( $Mdn = .62$ ).

**Woodcock-Johnson III Tests of Achievement (WJ-III).** The WJ-III was used both as a measure of decoding (at Time 1 and Time 2) and as a measure of reading comprehension (at Time 2). For decoding, the Letter-Word Identification and Word Attack subtests were given, which are measures of phonics skills. For fluency, the Reading Fluency subtest was administered. Letter-Word Identification requires the child to identify letters and read words. The Word Attack subtest requires children to sound out non-words. The Reading Fluency subtest requires the child to read through a short statement and determine if the statement is true or false; they are asked to read through as many statements as they can in three minutes. This is the only subtest that includes a time requirement.

The outcome measure in this study was the Passage Comprehension subtest. This subtest requires the child to perform multiple tasks: first, he or she is asked to match picture representations of objects with an actual picture of those objects (e.g., “chair”). In

the next set, he or she is asked to perform similar tasks, but with phrases (e.g., “yellow bird”). The last set of tasks is cloze reading tasks, where the child reads a short passage and fills in a blank with a word.

The WJ-III is a reliable and valid measure of reading achievement. The four subtests used in this study (Letter-Word Identification, Word Attack, Reading Fluency, and Passage Comprehension) have high test-retest reliability coefficients: .94, .87, .90 and .88, respectively. Test-retest reliability has been assessed for the timed speed tests, of which one (Reading Fluency, .94) was used in this study. The WJ-III also has high criterion validity and is highly correlated with other measures of reading skills, including the reading composite of the Wechsler Individual Achievement Test (WIAT; .82). The reading comprehension sections of the WJ-III are highly correlated with the reading comprehension sections in the WIAT ( $r = .79$ ).

### **Data Analyses**

The analyses for this study were conducted in progression. First, performance on AIMSweb of participants in this sample of young children with ASD was compared to national norms to establish their use with students with ASD. Next, reading accuracy was compared to reading comprehension to examine this relationship in a younger sample of children with ASD. Then, performance on various AIMSweb measures was compared to child characteristics, as well as to WJ-III decoding measures. This correlational analysis led to a transition in analyses: while the first set of analyses focused on AIMSweb measures, the following analyses transitioned to the WJ-III reading subtests. First, the predictive ability of AIMSweb measures on reading comprehension was examined using

simple and hierarchical multiple regressions. Then, WJ-III decoding measures were entered first in a hierarchical regression that examined the additional variance accounted for in reading comprehension by child characteristics. Lastly, the differences between poor comprehenders and average comprehenders were examined.

The first analysis addressed whether ASD children perform at a level similar to TD children on AIMSweb measures, since they have not been validated for use with children with ASD (research question 1). To address how this sample of children with ASD compares to national norms on AIMSweb measures at Time 1, one-sample t-tests were run on each of the measures at each grade (LNF in pre-kindergarten; LNF in kindergarten; LNF, LSF, PSF, and NWF in first grade; and R-CBM in second grade) and comparisons were made to the respective norms. It was hypothesized that the sample would not be statistically different from national norms on any of these measures, since previous research has suggested that children with ASD have comparable decoding skills to TD children.

The second analysis addressed the relationship between reading accuracy and reading comprehension (both at Time 2) to compare the relationship in this sample to relationships found in samples of older TD children and children with ASD (research question 2). Correlations were run to examine the relationship of participants' end-of-the-year reading accuracy and end-of-the-year WJ-III Passage Comprehension. Reading accuracy was calculated at Time 2 using the number of words read correctly on the R-CBM passage, divided by the total number of words read. It was hypothesized that

reading accuracy would be moderately correlated with reading comprehension, but not at a level equivalent to the high correlation found in TD children.

The third set of analyses addressed the relationship between AIMSweb measures and child characteristics (research question 3a), as well as AIMSweb measures and decoding measures on the WJ-III, including Word Attack and Letter-Word Identification (research question 3b). Correlations were run to examine how performance on AIMSweb measures in this sample is related to child characteristics, e.g. oral language, IQ, social skills and problem behaviors, as well as to decoding measures on the WJ-III at Time 1. These correlations included all AIMSweb measures, as well as the CCC-2, CASL, WPPSI-III, CBCL (externalizing, internalizing, and total problems t-scores), and SSIS, which are the measures of child characteristics. This was an attempt to examine how the decoding skills and fluency skills of children with ASD are related to their core deficits, and whether their reading skills are central to their diagnosis. Additional correlations were run which included AIMSweb measures and the two decoding subtests, as well as the fluency subtest, on the WJ-III, all from Time 1. It was hypothesized that performance on AIMSweb measures would be moderately correlated with all child characteristics and measures of decoding. These analyses served as a transition from the fourth to the fifth set of analyses, which integrate Time 1 WJ-III decoding subtests as predictors of Time 2 reading comprehension.

For the fourth set of analyses, simple and hierarchical multiple regressions were run using AIMSweb measures (split up by grade) to predict WJ-III Passage Comprehension (research question 4). Separate regressions were run for each grade, all



with WJ-III Passage Comprehension at Time 2 as the outcome measure of reading comprehension. AIMSweb measures from Time 1 were included in each model as the predictor(s), dependent on grade. LNF was used in the pre-kindergarten model, as well as in the kindergarten model. For first grade, LNF, LSF, PSF, and NWF were entered in steps into a hierarchical regression, dependent on whether they were correlated with the outcome. R-CBM was included as the predictor for second grade. It was hypothesized that early literacy skills, as measured by AIMSweb, would be predictive of reading comprehension skills, but not at a level comparable to same-age TD peers.

The fifth set of analyses included child characteristics as predictors. The extent to which child characteristics (oral language, IQ, social skills and problem behaviors) improved the model was addressed through hierarchical multiple regressions (research question 5). Due to small sample sizes for AIMSweb measures split by grade, WJ-III decoding measures (Word Attack and Letter Word Identification) were used as measures of decoding in this analysis. Research has already suggested that decoding skills predict more variance in reading comprehension than other skills for young children, and that oral language predicts unique variance when reading comprehension is the outcome; therefore, the appropriate WJ-III subtest from Time 1 was entered at step 1, oral language from Time 1 was entered at step 2, and the remaining child characteristics were entered at step 3 to determine if they predicted any additional variance. It was hypothesized that oral language would predict reading comprehension above and beyond decoding skills in accordance with previous research, and that these other child characteristics would predict additional variance.

Previous research with children with ASD has demonstrated that oral language skills predict a unique amount of variance in reading comprehension in adolescents, but research has shown that oral language is more predictive when children are older and when their decoding is poor. To examine this relationship in this sample of young children with ASD, additional regression analyses were run to determine the different predictive ability of oral language for children with poor decoding skills versus children with average decoding skills (research question 5b). Participants were split into two groups: those with poor decoding skills (standard score less than or equal to 85) and those with average decoding skills (standard score greater than 85). Level of decoding ability was determined by performance on phonological awareness and phonics measures, including AIMSweb measures and WJ-III measures. However, not all children completed the same AIMSweb measures, so precedence was as follows: 1) performance on NWF, 2) performance on PSF for those who did not complete NWF, 3) performance on LNF for those who did not complete NWF or PSF, and 4) WJ-III Letter-Word Identification for those who did not complete NWF, PSF or LNF. This ensured that children were defined as “poor” decoders if they demonstrated below average performance on measures of age-appropriate skills. Two separate hierarchical multiple regressions were run for each group. WJ-III Letter-Word Identification was entered at step 1 for both groups, and oral language (CASL) was entered at step 2. The predictive ability of the groups’ decoding skills versus their oral language skills was compared. It was hypothesized that oral language would predict more variance in the outcome for the children with poor decoding

skills (since their decoding skills are not yet established) than for the children with average decoding skills (who just began to develop these skills).

The last set of analyses examined the differences in decoding and child characteristics of poor comprehenders versus average comprehenders (research question 6). To address these differences on measures of decoding and child characteristics, two methods of analysis were used: independent samples t-tests comparing groups and a logistic regression with a dichotomous reading comprehension outcome variable. To split the groups for comparison on the t-tests, as well as to create the new dichotomous variable for the logistic regression, participants were split into two groups, one of poor comprehenders (standard score equal to or less than 85 on WJ-III Passage Comprehension) who were recoded as “0,” and one of average comprehenders (standard score greater than 85 on WJ-III Passage Comprehension) who were recoded as “1.” Independent samples t-tests were run to compare performance on AIMSweb measures, as well as the measures of child characteristics. This research question examined differences in decoding, oral language, IQ, social skills, and problem behaviors for these groups defined by their outcome. It was hypothesized that the “poor comprehenders” would not be different on the decoding measures, but that they would display fewer oral language skills and social skills, more problem behaviors, and lower IQs.

A logistic regression was run with the new dichotomous reading comprehension variable as the outcome. Variables were entered in blocks; first, oral language (CASL), then IQ (WPPSI-III), then social skills (SSIS) and problem behaviors (CBCL), and last, decoding skills (WJ-III Letter-Word Identification). It was hypothesized that the

likelihood of being a poor comprehender would be greater for children with lower oral language, lower IQ, fewer social skills, more problem behaviors and fewer decoding skills.

## **Results**

The descriptive statistics for the sample are provided in Table 1. The large variation in the decoding skills of children in the sample should be noted when viewing the standard deviations (*SD*) of the AIMSweb early literacy measures, while the WJ-III early literacy measures display slightly above average means and less variation.

For all analyses except those in research question 1, the participants' scores on the AIMSweb tests of early literacy skills were first converted to standard scores with a mean of 100 and a standard deviation of 15 so they could be compared with other measures using the same scale. First, raw AIMSweb scores were converted to z-scores by subtracting the normative mean from each raw score and then dividing by the standard deviation of the AIMSweb norm group. This was done to create a distribution around the norm group, rather than the sample. Z-scores were then converted to standard scores with a mean of 100 and a standard score of 15 by multiplying by the standard deviation (15) and adding the mean (100).

### **RQ1: Comparing AIMSweb Scores to National Norms**

The data analyses used to examine how this sample of children with ASD compared to national norms on AIMSweb benchmark measures included one sample t-tests to determine the differences between the means of the sample and the AIMSweb national norm group, provided on the AIMSweb website. This was a preliminary analysis

to examine how children with ASD performed on AIMSweb measures, since research using CBM measures has not been conducted with this population. Groups were first split up by grade so that their raw scores on the AIMSweb measures were compared to grade-equivalent norms for LNF in pre-kindergarten; LNF in kindergarten; LNF, LSF, PSF, and NWF in first grade; and R-CBM in second grade. Because recruitment for the longitudinal study was ongoing, there was a range of dates that the data was collected for each wave of participants. Therefore fall grade-level norms were used as the population mean for the following reasons: (1) a large portion of the children in the sample were tested during the fall before the winter screening date in January (70%), (2) the fall benchmark is a more easily achievable goal, and therefore more acceptable for the whole group to be compared to, and (3) the groups could not have been separated by screening period because this would lead to much smaller sample sizes. The assumptions for a one-sample t-test were examined; the distribution of the sample on these measures appeared to be normal, and the participants were randomly sampled from the population. Results are provided in Table 2.

There were differences to note on performance on AIMSweb measures between children with ASD in the sample and the TD children in the population. First, the results of the t-test comparing pre-kindergarten (age 4;  $n = 40$ ) children on LNF indicated that there were differences between the sample mean and the population mean,  $t(39) = 5.20, p < .001$ . These differences were maintained in kindergarten (age 5;  $n = 28$ ) on LNF,  $t(27) = 4.45, p < .001$ . The t-tests computed for LNF for pre-kindergarten and kindergarten indicated that the sample means of children with ASD in pre-kindergarten and

kindergarten were both significantly higher than the AIMSweb norms means for both grades. However, the t-test for LNF in first grade (age 6;  $n = 29$ ) indicated that there were no differences between the ASD sample and the population mean,  $t(28) = -.65, p = .52$ . For first graders on LSF ( $n = 34$ ), an early indicator of phonics skills, differences emerge,  $t(33) = -3.97, p < .001$ . This time, however, the results for LSF showed that children in the ASD sample performed significantly lower than children in the normative group. The same was evident for first graders on PSF ( $n = 35$ ), a measure of phonological awareness,  $t(34) = -8.21, p < .001$ . However, no differences emerged for first graders on NWF ( $n = 33$ ), a measure of phonics,  $t(32) = .09, p = .93$ . The results of the t-test comparing R-CBM ( $n = 14$ ), a general outcome measure, suggested that there was no significant difference in this sample from the population mean,  $t(13) = -.89, p = .39$ .

When simply comparing means, it appeared that children with ASD can actually display below average decoding and fluency skills early on, but these skills also vary quite a bit, as indicated by the standard deviations reported in Table 2. Participants' performance on AIMSweb can also be analyzed by determining whether participants reached a certain criterion that would indicate future success, since AIMSweb is a criterion-referenced measure (Shinn & Shinn, 2002a; 2002b). These criteria are called "benchmarks" and there are three categories: benchmark (indicating performance on the measure that suggests 80% likelihood of later reading success), strategic (indicating performance on the measure that suggests 50-80% likelihood of later reading success), and intensive (indicating performance on the measure that suggests less than 50% likelihood of later reading success). The appropriate fall screening benchmark scores

were used for each grade. Results are presented in Table 3. While 71.4% of pre-kindergarten, kindergarten and first grade students performed at or above their grade-appropriate benchmark on LNF, only 35.3%, 17.1%, 40.6%, and 33.3% of students performed at or above benchmark on LSF, PSF, NWF, and R-CBM, respectively. The results of these analyses suggest that there is some variability in the development of early literacy skills in this sample of young children with ASD, and some of these skills appear to develop out of concert.

### **RQ2: Reading Accuracy and Reading Comprehension**

To examine the extent to which reading accuracy was correlated with reading comprehension, additional correlations were run between Time 2 reading accuracy and Time 2 reading comprehension for all participants who completed both measures at Time 2 ( $n = 54$ ). Reading accuracy was calculated on AIMSweb R-CBM by dividing the words read correctly by the total number of words read. Accuracy on R-CBM ( $M = .76$ ,  $SD = .29$ ) was found to be correlated with WJ-III Passage Comprehension,  $r(53) = .56$ ,  $p < .001$ . This relationship represents a moderate correlation according to Cohen (1988), and is almost identical to the correlation reported in 2006 by Nation and colleagues ( $r = .57$ ).

### **RQ3a: Decoding Skills on AIMSweb and Child Characteristics**

To examine the extent to which performance on AIMSweb measures was correlated with child characteristics, correlations were run amongst all of the AIMSweb measures (split up by measure: LNF, LSF, PSF, NWF and R-CBM) and child characteristics, including: oral language performance on the CASL, oral language assessment through the CCC-2, social skills as measured by the SSIS, problem behaviors

as measured by the CBCL, and cognitive functioning as measured by the WPPSI-III. All of these measures were collected at the first time point, with the exception of the CCC-2 and the WPPSI, which were collected during the eligibility visit. The correlations are provided in Table 4.

Oral language skills (child performance as demonstrated on the CASL rather than parent report) and cognitive functioning as indicated by full-scale WPPSI-III IQ were the child characteristics most highly correlated with decoding and fluency skills, as both were correlated with all AIMSweb measures. However, some other child characteristics did seem to be correlated with different decoding skills. Parent report of the child's oral language on the CCC-2 was correlated with LSF,  $r(31) = .39, p < .05$ ; PSF,  $r(32) = .42, p < .05$ ; and with NWF,  $r(32) = .42, p < .05$ . Additionally, externalizing problem behaviors were significantly correlated with NWF,  $r(29) = .39, p < .05$ , as well as with PSF,  $r(31) = .41, p < .05$ . Total problem behaviors,  $r(31) = .39, p < .01$ , and internalizing problem behaviors,  $r(31) = .35, p < .05$ , were also correlated with PSF, making PSF the most highly correlated AIMSweb measure in relation to child characteristics. Although autistic mannerisms on the SRS were significantly correlated with all other child characteristics except performance on the CASL, they were not correlated with any of the AIMSweb measures of reading skills. Phonological awareness skills, in particular, appeared to be highly related to most of these other characteristics.

### **RQ3b: AIMSweb Measures and WJ-III Measures**

The analyses for research question 3b, the extent to which performance on AIMSweb was correlated with performance on WJ-III measures of decoding, mimicked



those of research question 3a. Correlations were run to examine the relationship between all of the AIMSweb measures, split up by measure, and the measures of decoding administered from the WJ-III, which included Letter-Word Identification and Word Attack. These relationships were examined to see if these tests, using different methods, produced similar results. Of interest to this research question are the correlations between tools that measure the same or similar skills (i.e., WJ-III Letter-Word Identification and AIMSweb LSF and NWF, WJ-III Word Attack and AIMSweb LSF and NWF, and WJ-III Reading Fluency and AIMSweb R-CBM).

The results of these correlational analyses indicated that AIMSweb measures and their WJ-III counterparts are highly correlated in this sample of children with ASD (Table 5). The WJ-III Letter-Word Identification subtest was correlated with all AIMSweb early literacy measures, but was most highly correlated with NWF ( $n = 33$ ), a non-word reading task measuring phonics,  $r(31) = .76, p < .01$ . Letter-Word Identification was also highly correlated with R-CBM ( $n = 14$ ), a general outcome measure,  $r(12) = .79, p < .01$ . The WJ-III Word Attack subtest was similarly correlated with all AIMSweb early literacy measures, and was also most highly correlated with NWF ( $n = 32$ ),  $r(30) = .71, p < .01$ . This association is logical given that WJ-III Word Attack and AIMSweb NWF are both non-word reading tasks that measure phonics skills. Beyond these early literacy measures, Word Attack was also correlated with R-CBM,  $r(12) = .68, p < .01$ . The relationship between Word Attack and Letter-Word Identification was also of interest because it was quite strong,  $r(94) = .80, p < .001$ . The WJ-III Reading Fluency subtest was correlated with all AIMSweb measures except PSF;

perhaps more importantly, it was correlated with AIMSweb R-CBM ( $n = 10$ ),  $r(8) = .78$ ,  $p < .01$ . These results indicate that AIMSweb and the WJ-III are correlated, especially when their equivalent measures are compared.

#### **RQ4: Decoding Skills Predicting Reading Comprehension**

To address the variance in reading comprehension accounted for by AIMSweb measures, one regression analysis was run for each grade level (pre-kindergarten, kindergarten, first grade and second grade) using the grade-appropriate AIMSweb measures as predictors. WJ-III Passage Comprehension was the outcome measure of reading comprehension for all regressions. The results for these regressions are provided in Table 6. Power analyses were run with power set at .8 to determine the number of participants necessary to run the proposed regression analyses. Unless otherwise noted, power for the following analyses was adequate to find the medium effects previously found in the literature.

The assumptions of regression (normality, linearity, homoscedasticity, and outliers) were checked for each regression and the results for each were recorded. Normality was observed through an examination of the normal probability plot; linearity was examined by plotting the residuals against the predicted values; homoscedasticity was also reviewed in this residuals plot, where it was expected that data form a pattern around the value of zero. The additional assumption of multicollinearity was checked for the multiple regressions run on the first grade data and WJ-III. For the following analyses, all of the assumptions were met unless otherwise noted.

The first regression included LNF as the predictor ( $M = 116.30$ ,  $SD = 17.03$ ) and WJ-III Passage Comprehension ( $M = 101.85$ ,  $SD = 15.81$ ) as the dependent variable. For this regression, only participants who were age 4 and in pre-kindergarten were included in the analyses ( $n = 40$ ). The normal probability plot appeared normal, as did the plot of the residuals; however, once the scores were converted to z-scores, there appeared to be an outlier. This participant was removed from the sample ( $n = 39$ ,  $M = 116.24$ ,  $SD = 17.25$ ). The results of the regression indicated that LNF in pre-kindergarten did not account for a significant portion of the variance in reading comprehension,  $R^2 = .07$ ,  $F(1, 37) = 2.87$ ,  $p = .10$  (Table 6).

The second regression using LNF ( $M = 114.06$ ,  $SD = 16.73$ ) as a predictor for WJ-III Passage Comprehension ( $M = 103.71$ ,  $SD = 15.47$ ) for kindergarten students, age 5 ( $n = 28$ ), produced similar results. LNF at the beginning-of-the-year in kindergarten did not predict a significant amount of variance in reading comprehension,  $R^2 = .09$ ,  $F(1, 26) = 2.49$ ,  $p = .13$  (Table 6).

A hierarchical multiple regression was run for first grade students, age 6 ( $n = 33$ ), and initially included all of the AIMSweb measures (LNF, LSF, PSF, and NWF). However, there were high correlations between some of the predictor variables, indicating a violation of the assumption of multicollinearity. For this reason, LSF was eliminated from the model because of its high correlation with PSF ( $r = .71$ ) and PSF's higher correlation with the outcome ( $r = .59$ ). Therefore, only LNF ( $M = 99.22$ ,  $SD = 24.04$ ), PSF ( $M = 80.45$ ,  $SD = 14.70$ ) and NWF ( $M = 100.44$ ,  $SD = 28.45$ ) were entered into the hierarchical regression. Due to research in TD children suggesting that NWF

predicts more variance in reading comprehension than PSF or LNF (as well as NWF's higher correlation in this study with the outcome), NWF was entered at step 1, PSF was entered at step 2, and LNF was entered at step 3. NWF significantly predicted reading comprehension ( $\beta = .73, p < .001$ ) and was the only variable entered into the model. Therefore, only NWF was entered into the final model as a predictor. Alone, NWF accounted for 54% of the variance in reading comprehension,  $R^2 = .54, F(1, 31) = 35.69, p < .001$  (Table 6).

For second graders, R-CBM ( $M = 95.05, SD = 20.92$ ) was used in the regression to predict reading comprehension for 14 participants ( $M = 88.07, SD = 17.48$ ). R-CBM was a significant predictor of WJ-III Passage Comprehension ( $\beta = .57, p < .05$ ) predicting 32% of the variance in reading comprehension,  $R^2 = .32, F(1, 12) = 5.68, p < .05$  (Table 6). However, it should be noted that the sample size for this analysis was small ( $n = 14$ ).

### **RQ5: Child Characteristics, Decoding Skills and Reading Comprehension**

Hierarchical multiple regressions were run to examine how child characteristics at Time 1, such as oral language skills, IQ, social skills, and problem behaviors, predict reading comprehension above and beyond literacy measures ( $n = 106$ ). These analyses addressed the question of whether the model predicting reading comprehension could be further improved for this sample of young children with ASD.

Due to small sample sizes in AIMSweb when split by grade, WJ-III decoding measures (Word Attack and Letter-Word Identification) were used as decoding measures for this analysis. Previous analyses demonstrating that AIMSweb and the WJ-III were correlated provided the impetus for this analysis. Problem behaviors were narrowed down

to externalizing behaviors since externalizing behaviors were correlated with more reading skills. Additionally, only the CASL was included as the measure of oral language because it was more highly correlated with the reading measures than the CCC-2. Autism symptom severity was not included because it was not significantly correlated with the reading skills. Although all other assumptions were met, the assumption of multicollinearity was violated due to the high correlation between Letter-Word Identification and Word Attack ( $r = .80$ ). Due to the fact that both Letter-Word Identification and Word Attack had similarly high correlations with the outcome (.57 and .59, respectively), Letter-Word Identification was the only subtest retained in the model because more children completed this subtest ( $n = 114$ ) than did Word Attack ( $n = 96$ ).

For young children who are first developing their decoding skills, decoding skills predict more variance in reading comprehension than do oral language skills (Foorman et al., 1997; Hoover & Gough, 1990; Perfetti, Landi & Oakhill, 2005; Rathvon, 2004). However, oral language skills have been shown to predict unique variance in reading comprehension. Therefore, a hierarchical regression was run with WJ-III Letter-Word Identification entered at step 1 to control for decoding skills, oral language skills on the CASL entered at step 2, and the remaining child characteristics (cognitive functioning on the WPPSI-III, externalizing behavior problems on the CBCL, and social skills on the SSIS) entered at step 3. Again, WJ-III Passage Comprehension was the outcome. The results of the regression suggest that the model is improved by the addition of oral language and IQ. Therefore, the regression was limited to WJ-III Letter-Word Identification entered at step 1, CASL entered at step 2, and WPPSI-III entered at step 3

( $n = 112$ ). While Letter-Word Identification alone predicted 31% of the variance, oral language and IQ accounted for an additional 11% of the variance in WJ-III Passage Comprehension (Table 7). The final model included decoding skills ( $\beta = .44, p < .001$ ), oral language ( $\beta = .17, p = .12$ ), and IQ ( $\beta = .21, p < .05$ ) as the best predictors for reading comprehension in this sample. Together, they accounted for 42% of the variance in reading comprehension,  $R^2 = .42, F(3, 108) = 26.06, p < .001$  (Table 7).

For the following analysis, the group was split between poor decoders and average to above average decoders to examine the impact of oral language skills (previously found to be significant in older children with ASD) for children with average decoding skills versus children with poor decoding skills. The first hierarchical regression was run for poor decoders ( $n = 18$ ). WJ-III Letter-Word Identification was entered at step 1 and oral language was entered at step 2. WJ-III Letter-Word Identification was the only significant predictor ( $\beta = .54, p < .05$ ) of reading comprehension for poor decoders, predicting 30% of the variance,  $R^2 = .30, F(1, 16) = 6.77, p < .05$  (Table 8, model 1: poor).

The second hierarchical regression was run for average to above average decoders ( $n = 95$ ). Again, WJ-III Letter-Word Identification was entered at step 1, and oral language on the CASL was entered at step 2. For these average decoders, both WJ-III Letter-Word Identification ( $\beta = .38, p < .001$ ) and oral language on the CASL ( $\beta = .30, p < .001$ ) were found to be significant, and predicted 31% of the variance in reading comprehension,  $R^2 = .31, F(2, 92) = 20.65, p < .001$  (Table 8, model 2: average). Decoding skills were less predictive of reading comprehension for average

comprehenders than for poor comprehenders, and oral language was only significant for average decoders.

### **RQ6: Poor Comprehenders vs. Average Comprehenders**

The last research question, how poor comprehenders compared to average and above average comprehenders on measures included in the study, was an attempt to describe differences between the two groups. Twenty-five participants (21%) were identified as poor comprehenders based on their performance on WJ-III Passage Comprehension. These groups were compared on their performance on multiple measures, including CCC-2, CASL, WPPSI-III, CBCL, SSIS, SRS and AIMSweb in order to determine if there were consistent differences between groups across the domains of oral language skills, IQ, problem behaviors, social skills, decoding skills, and general reading skills. Additionally, a logistic regression was run with the dichotomous reading comprehension variable (poor or average comprehension) as the outcome.

Independent sample t-tests were run to determine if there were statistically significant differences in performance on these measures. Because the assessment window was somewhat wide, a preliminary t-test was run to determine if the groups were different in terms of when they were administered these measures; if either group had been administered the measures significantly later in the school year, higher performance could then be attributed to that factor. However, the groups were no different in terms of when the measures were administered.

It was assumed that variances of the groups were equivalent. Levene's test for equality of variances was examined for each t-test to determine if the variance of the

sample of poor comprehenders was equivalent to that of the average comprehenders; for cases in which the null hypothesis was rejected and the variances were statistically different, equal variances were not assumed and the appropriate statistic was used (i.e., the *t* statistic for unequal variances). Statistical differences did emerge for a number of measures (Table 9). First, both measures of oral language showed differences between poor comprehenders and average comprehenders; the differences that emerged on the CCC-2,  $t(114) = 2.39, p < .05$ , and on child performance on the CASL,  $t(100) = 3.80, p < .001$ , suggested that the oral language skills of the average comprehenders was significantly higher than those of the poor comprehenders. Differences also emerged for IQ, suggesting that average comprehenders had a higher mean IQ than poor comprehenders,  $t(117) = 4.21, p < .001$ . However, 62.5% of children in the poor comprehenders group had a typical IQ (i.e., 70 or above).

The comparison between means on the CBCL, SRS and SSIS yielded different results. There were no differences between poor and average comprehenders on internalizing behaviors,  $t(109) = .20, p = .84$ , externalizing behaviors  $t(109) = -1.105, p = .27$ , or total problem behaviors  $t(110) = -1.07, p = .29$ , indicating that poor and average comprehenders displayed similar levels of problem behaviors. Similarly, poor and average comprehenders displayed similar autism symptom severity on the SRS,  $t(110) = 1.36, p = .18$ . As for social skills, a marginally significant difference emerged between groups,  $t(117) = 1.89, p = .06$ , indicating slightly higher social skills in the average comprehenders.



Despite prior research that provides evidence to the contrary, differences emerged between groups on measures of decoding skills. In particular, the average comprehenders had higher scores on LNF,  $t(96) = 2.03, p < .05$ , as well as on LSF,  $t(22.15) = 2.60, p < .05$ , and NWF,  $t(32.81) = 4.72, p < .001$ , which are all measures of early phonics skills. Average comprehenders also appeared to perform at a higher level than poor comprehenders on PSF,  $t(32.81) = 4.72, p < .001$ , which is a measure of phonological awareness. There were no differences between groups on R-CBM, a general outcome measure of fluency,  $t(12) = 4.37, p = .27$ . Conversely, the average comprehenders had greater reading accuracy than the poor comprehenders,  $t(11.93) = 4.28, p < .001$ , although there was a wider range of reading skills in the poor comprehenders group. In summary, the average comprehenders outperformed the poor comprehenders on every measure of decoding and reading except R-CBM.

The final model produced by the logistic regression fit poorly with the data (Table 10). None of the predictors made a significant contribution to the prediction of the outcome. The variables were not able to predict membership in the poor versus average comprehension group.

### **Discussion**

The results of these analyses suggest a number of things about the reading development of children with ASD. First, it is clear that performance on AIMSweb of the sample of children with ASD is different from national norms; however, it is similar to performance seen in other studies of children with ASD (Gabig, 2010; Huemer & Mann, 2010; Minshew et al., 1994; Nation et al., 2006; Norbury & Nation, 2011; Ricketts et al.,

2013). Second, AIMSweb measures were correlated with a standardized and norm-referenced reading measure, the WJ-III, as well as with select child characteristic measures. These relationships among discrete reading skills and multiple child characteristics examined here have not been previously indicated in the literature. Third, AIMSweb measures and WJ-III measures were separately shown to predict end-of-the-year reading comprehension; furthermore, child characteristics tended to improve the model (Table 7), particularly for average decoders (Table 8). The results of this study both support and expand on previous research in the area of reading development in children with ASD.

### **Comparing AIMSweb Scores to AIMSweb National Norms**

The results indicate that the AIMSweb performance of this sample of children with ASD (4 to 7 years old) differed from national norms (Table 2). Children in this sample in pre-kindergarten and kindergarten performed at a higher level than the normative sample on letter naming fluency (LNF); however, this difference disappeared for students in first grade, since other components of reading become more important by this time. First graders in this sample performed at a level lower than the national norm sample on letter-sound fluency (LSF), an early measure of phonics, and on phoneme-segmentation fluency (PSF), a measure of phonological awareness. However, the sample did not differ from the national norms on nonsense-word fluency, a non-word reading task that measures phonics. The second graders in this sample did not differ from the national norms on reading fluency (as measured by R-CBM).

Nation and colleagues (2006), in their sample of older children ( $M = 10.85$  years), posited that components of reading develop out of concert in ASD; while some skills related to decoding ability seem to be relatively intact, children with ASD may demonstrate much more variable performance on other skills (Davidson & Weismer, 2013). The results of the t-tests examining differences between this sample's performance on AIMSweb and the normative sample can inform our understanding of how these components of literacy develop during the early years of schooling. While some research has suggested that the decoding skills of children with ASD are above average (Huemer & Mann, 2010; Mayes & Calhoun, 2003), other research has emphasized the variability in these skills; however, this is typically shown in samples with a wide range of ages (10 to 16 years).

Regarding the higher performance on LNF by this sample of children with ASD, past studies have suggested that children with ASD generally perform higher than their same-age TD peers on "procedural" measures of print-related competencies such as letter naming, specifically (Lanter et al., 2012). Lanter and colleagues (2012) assessed the procedural (e.g., letter knowledge and letter sound knowledge) and conceptual (e.g., knowledge about reading) skills that the child had and found that children with ASD performed at a higher level than TD children on measures of letter naming. These results extended the findings of Markowitz et al. (2006), who found that children with ASD performed significantly higher than TD children on WJ-III Letter-Word Identification, which measures both letter naming and word reading. Additionally, it has been hypothesized that these strengths in word reading skills are connected with a

preoccupation with printed words (Nation et al., 2006). This would explain the high LNF scores in this sample. Therefore, the findings of this study extend previous research, which suggests that letter naming ability of children with ASD is higher than that of same-age peers, to performance on criterion-referenced CBM measures; namely, AIMSweb. However, this difference did not continue into first grade, suggesting that differences in letter naming dissolve as phonological awareness and more complex phonics skills begin to take precedence.

Children in this study's ASD sample performed significantly lower than national norms on PSF, the AIMSweb measures of phonological awareness; this result can be interpreted in different ways. First, their overall poor performance can be suggestive of a significant deficit, in relation to other component skills of reading, in children with ASD. Although research in the area of phonological awareness in ASD is lacking, the available research suggests that these skills are limited in this population. Gabig (2010) found that children with ASD performed significantly lower than typically developing (TD) controls on a well-established measure of phonological awareness. Furthermore, Heimann et al. (1995) demonstrated that children with ASD performed at a level significantly lower than TD controls and another comparison group of children with other disabilities.

Another possible interpretation of these results is that the procedures of PSF (and other measures of phonological awareness) are particularly challenging for children with ASD, who already have trouble following oral directions (Minshew et al., 1994). Although directions are given orally for all AIMSweb measures (and most measures of reading skills, for that matter), PSF is a measure that is administered entirely orally, given

the nature of phonological awareness. This could present challenges for children with ASD, who might have trouble paying attention and staying motivated to complete tasks without reward (Koegel, Koegel & Smith, 1997), especially when there is no visual stimulus, which could contribute to their overall poor performance on this measure.

While research on phonological awareness in ASD is limited, a large majority of research focuses on phonics, usually in the form of non-word reading tasks. These tasks rely more heavily on decoding rather than word recognition. The AIMSweb NWF measure is a non-word reading task, which makes the results of this study highly comparable to previous studies. Some research has suggested that non-word reading skills in ASD are in excess of word reading skills (Minsheu et al., 1994), while other research has suggested the opposite is possible (Nation et al., 2006). The results of these analyses suggest that the non-word reading skills of this sample on NWF were no different from the national norm sample of TD children. Rather than displaying unexpectedly high decoding skills, this sample of young children with ASD displayed similar ability to TD children. Furthermore, some research has suggested that this relationship is different dependent on language ability (Norbury & Nation, 2011) or on hyperlexic status (Newman et al., 2007); children with ASD with no language impairment have been found to have higher decoding skills than those with language impairment (Norbury & Nation, 2011) and children with ASD and hyperlexia have been found to have higher decoding skills (Newman et al., 2007) than those without hyperlexia. The AIMSweb comparisons for this sample were not split by language ability or hyperlexic status, which might explain why these differences did not emerge.

These results on NWF were in contrast to the overall poor performance on PSF (Figure 1). Nation et al. (2006) predicted that the children with the poorest phonological awareness would also have the poorest phonics skills. Although this may be true, there was far more underachievement on PSF than there was on NWF, and far more overachievement on NWF than there was on PSF, further emphasizing the point that component reading skills do not develop in concert in children with ASD, even in the early school years.

Related to fluency, children with ASD performed no differently from national norms on the AIMSweb R-CBM measure, which are similar to the results found for phonics. This suggests that phonics and fluency in ASD develop similarly to phonics and fluency in TD children. However, it is important to note that the variance in performance is much greater for children with ASD on both of these measures. This means that although average performance is similar, there are more children with ASD who perform far below the mean, and more children with ASD who perform far above the mean. The latter phenomenon can be explained by the purported preoccupation with printed words that is often exhibited by children with ASD (Nation et al., 2006). However, the extreme underperformance is a phenomenon not often noted in research on reading development in ASD, but it could be related to oral language performance, similar to reading comprehension.

One of the purposes of this question was to examine if the results of these analyses with AIMSweb measures were similar to the results of similar analyses in other studies using different measures of reading. The results suggest that AIMSweb measures

produce similar results to other measures of reading in regards to phonics and fluency for children with ASD. This is an important finding because of the speed and ease of use of the AIMSweb measures, and their increasing use in schools to monitor reading progress. However, reading skills in general might develop out of concert (Davidson & Weismer, 2013; Nation et al., 2006). For instance, the phonological awareness skills displayed by first graders in this sample was significantly lower than national norms, despite typical phonics skills. Additionally, as displayed in Table 3, there is a lot of variance in the sample and a lot of students are participating at a level lower than benchmark on all measures except for LNF.

### **Reading Accuracy and Comprehension**

Reading accuracy in this sample of children with ASD was moderately correlated with reading comprehension ( $r = .56$ ), despite adequate accuracy ( $M = .76$ ). In the literature, reading accuracy has been found to be a critical element in developing reading comprehension skills (Chard et al., 2002), and is highly correlated with various measures of reading comprehension in TD children (.81 to .87; Nation & Snowling, 1997). This reflects back on Perfetti's efficiency model (1985) which suggests that slow decoding (and therefore low accuracy) would hinder reading comprehension; automatic decoding and high accuracy would free up cognitive resources to focus on comprehending text.

This sample of young children with ASD displayed almost the exact same relationship between reading accuracy and reading comprehension as Nation et al.'s (2006) sample of older children ( $M=10.85$  years) with ASD, suggesting that this relationship emerges in early childhood and continues as more advanced reading skills

are developed. Both of these samples displayed correlations between .56 and .57, weaker than correlations typically found in TD children (Nation & Snowling, 1997), suggesting that reading accuracy is not as highly linked to reading comprehension outcomes for children with ASD as it is for TD children.

### **Correlations between Decoding Skills and Child Characteristics**

The correlations ran revealed how reading skills were related to child characteristics (Table 4). Performance on LNF (for pre-kindergarten, kindergarten and first grade) was only correlated with oral language skills and IQ (cognitive functioning). Of particular interest is that the correlations between AIMSweb measures and IQ and oral language were consistent for LSF, PSF, and NWF, as well, suggesting that performance on early literacy measures is related to the child's cognitive level and oral language skills. Also of interest was that PSF was the only measure that was significantly correlated with problem behavior scores on the CBCL. However, the relationship was positive, indicating that as performance on PSF increased, externalizing behavior problems increased (on the CBCL). This suggests that contrary to the proposed hypothesis, problem behaviors do not disrupt performance on PSF in a negative way.

Interestingly, the CASL was correlated with more measures of reading than the CCC-2, although both measure oral language skills. While the subtests on the CASL chosen for this study are primarily measures of expressive language, the CCC-2 measures both receptive and expressive language. Contrary to research in TD children and adolescents, expressive oral language is more highly correlated with reading skills in children with ASD than receptive language (Davidson & Weismer, 2013). The CCC-2



was also correlated with PSF, a phonological awareness measure, and NWF, a phonics measure. Furthermore, past research has suggested that this relationship exists in a similar sample of children with ASD (Gabig, 2010). Gabig (2010) found that receptive oral language as measured by the PPVT was correlated with an elision task (e.g., eliminating sounds from words) from the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999), which measures phonological awareness.

Surprisingly, autistic mannerisms were not correlated with any of the AIMSweb decoding measures, despite prior research suggesting that autism symptom severity is correlated with reading skills (Davidson & Weismer, 2013; Huemer & Mann, 2010; Jones et al., 2009). Previous literature has examined symptom severity based on observations on the ADOS, or on diagnostic group, while the analysis in the present study used parent report on the SRS, which examines a large variety of autistic-related symptoms. This might account for some of these differences.

### **Correlations between AIMSweb and WJ-III**

The purpose of the correlations between AIMSweb measures and WJ-III measures was to examine whether they measure similar skills in children with ASD, since measures like the WJ-III are more commonly used in research on reading development in ASD. All of the measures were significantly correlated with one another, but the most interesting correlations were those that measured the same or similar skills (Table 5). For instance, PSF and NWF, both decoding measures, were highly correlated with Letter-Word Identification and Word Attack on the WJ-III, with the highest correlation between Letter-Word Identification and NWF. This was interesting, since Letter-Word

Identification is a word reading measure, while NWF is a non-word reading measure and more closely resembles Word Attack. However, this can be explained by the high correlation between Letter-Word Identification and Word Attack, which suggests that children in this sample have comparative word reading and non-word reading skills. This extends the finding that this sample's mean performance on NWF was no different from the population norm performance. These results suggest that these skills, at least, might develop in concert in this sample of young children with ASD.

### **Decoding Skills Predicting Reading Comprehension**

The results of the regression analyses run with AIMSweb measures demonstrated different outcomes for different component skills across the early grades (Table 6). For example, LNF did not predict reading comprehension for children in pre-kindergarten or kindergarten, but NWF was the best predictor of reading comprehension for first graders. Finally, R-CBM significantly predicted reading comprehension for second graders. Similar analyses in research on TD students have examined the predictive ability of all AIMSweb measures on reading comprehension in students within the same grade (Burke et al., 2009; Kim et al., 2010; Riedel, 2007). The purpose of these analyses was to show how these relationships progress throughout the early school years for children with ASD, and to determine how these relationships compare to the relationship between WJ-III and reading comprehension.

First, LNF was not found to be predictive of reading comprehension outcomes for pre-kindergarten or kindergarten children. In TD children, knowledge of letter names is typically seen as an indicator of reading outcomes (Adams, 1990); however, knowledge

of letter names is not important in developing strong reading skills, and is therefore not typically predictive of reading comprehension. Thus, it is not surprising that LNF did not predict reading comprehension skills, especially for children who are so young.

Although AIMSweb measures were not predictive for children in pre-kindergarten and kindergarten, NWF was a significant predictor of reading comprehension for participants in first grade. Studies conducted with TD children typically suggest that of the AIMSweb and DIBELS early literacy measures (i.e., measures other than R-CBM or ORF), NWF is the most predictive of reading comprehension (Burke et al., 2009; Riedel, 2007). The results of this analysis suggest that performance on NWF predicts reading comprehension for TD children and children with ASD similarly well. These results simply demonstrate that measures gathered in first grade are predictive of end-of-the-year reading comprehension for children with ASD.

In second grade, R-CBM predicted significant variance in reading comprehension in this sample. When examining CBM measures and their predictive ability, it is often found that R-CBM and other oral reading fluency measures are highly correlated with reading comprehension measures (Fuchs, Fuchs, & Maxwell, 1988; Shinn, Good, Knutson, Tilly & Collins, 1992), that R-CBM (or ORF) is the best predictor of reading comprehension (Riedel, 2007), and that changes in reading fluency impact changes in reading comprehension (Markell & Deno, 1997; Neddenriep, Fritz, & Carrier, 2011). The predictive ability of reading fluency on reading comprehension is not often a central focus in studies of children with ASD; more often, word-level reading or word recognition are used as predictors, rather than text-level reading. For this sample,

performance on R-CBM was as predictive of reading comprehension outcomes as it is in TD children.

### **Decoding Skills and Child Characteristics**

Hierarchical multiple regressions were run to determine the role of child characteristics in predicting reading comprehension for young children with ASD. Results indicated that when predicting end-of-the-year reading comprehension, adding oral language skills and IQ as predictors alongside beginning-of-the-year decoding skills (WJ-III Letter-Word Identification) improved the model. These results extend previous literature suggesting that oral language is a significant predictor of reading comprehension in a younger group of children with ASD, and suggest that cognitive functioning might also be an important factor for younger children. In addition, this study provides evidence for the use of the simple view of reading in children with ASD, which suggests that reading is the product of decoding and listening comprehension (Gough & Tunmer, 1986), although cognitive functioning appears to play a role in reading comprehension, as well.

The significance of oral language in reading comprehension found in the present study has also been demonstrated in adolescents with ASD (Nation et al., 2006; Norbury & Nation, 2011; Ricketts et al., 2013). Although the predictive ability of oral language on reading skills, including reading comprehension, has been examined in younger children, it was not analyzed alongside decoding skills (Davidson & Weismer, 2013). Therefore, these results show that the low oral language skills demonstrated by many children with

ASD (Lindgren et al., 2009; Nation et al., 2006) may contribute to limited reading comprehension, beyond decoding skills.

Although research in adolescents with ASD has suggested that social skills predict reading comprehension alongside oral language and decoding skills (Ricketts et al., 2013), research in younger children with ASD has suggested that cognitive functioning (specifically, nonverbal cognition) might be an important predictor (Davidson & Weismer, 2013). These results support that finding. Similar to Davidson and Weismer (2013), the present study found that cognitive functioning improved the model in addition to oral language skills and decoding skills. Davidson and Weismer determined that although expressive language was predictive of reading comprehension, receptive language was not a significant predictor for their group of young children with ASD, possibly due to the typical discrepancy between expressive and receptive language in children with ASD (where expressive language tends to be higher), as well as the possibility that children with higher expressive language have more opportunities to engage in reading activities. Although the distinction between expressive and receptive oral language skills was not made in the present study, the subtests used on the CASL are primarily measures of expressive language (Carrow-Woolfolk, 2008), so these findings were supported.

Dissimilar from Davidson and Weismer (2013), however, was that the present study demonstrated that overall cognitive functioning, rather than nonverbal cognition, was a significant predictor in the model. The measure of cognitive functioning used in the present study is more indicative of overall IQ. Additionally, Davidson and Weismer did

not include decoding measures as predictors, but rather as outcomes alongside more comprehension-related tasks.

Furthermore, the results of the separate regressions run for poor versus average decoders suggested that oral language is more predictive for the average decoders than for the poor decoders, for whom oral language predicted no additional unique variance in reading comprehension above and beyond established decoding skills. Research on TD children supports this finding, although the discussion of this discrepancy tends to revolve around age rather than level of decoding skill. Previous research on TD children has suggested that as children develop more literacy skills, oral language skills become more important (Nation & Snowling, 1997). In fact, Storch and Whitehurst (2002) purported that while oral language has a clear role for older children (e.g., those who have established decoding skills), it is more questionable in the early stages of reading. When Storch and Whitehurst (2002) examined the relationship in younger children (grades 1 and 2), they found that first and second grade oral language skills had no impact on concurrent reading skills, suggesting that the relationship between oral language and reading skills is not as strong in younger children. The present study distinguishes between poor and average decoders in this young sample to suggest that the predictive ability of oral language on reading comprehension is more apparent in students with well-developed decoding skills. Therefore, these results suggest that the predictive ability of oral language on reading comprehension does not just develop with age, but rather with decoding ability, consistent with Perfetti's (1985) efficiency model which suggests that reading comprehension increases as decoding skills become automatic.

### **Poor versus Average Comprehenders**

The results of the independent samples t-tests indicate that poor comprehenders and average comprehenders differed on most measures of child characteristics and reading skills, including: oral language (CCC-2 and CASL), IQ (WPPSI-III), decoding skills (AIMSweb LNF, LSF, PSF, and NWF), and accuracy on AIMSweb. The two groups did not differ on social skills (SSIS), problem behaviors (CBCL), or fluency (AIMSweb R-CBM).

This analysis is comparable to an analysis conducted by Nation and colleagues (2006) that examined differences between skilled and less-skilled comprehenders in their sample of adolescents with ASD. First, 65% of their total sample had poor comprehension skills (at least 1 *SD* below the mean of 100); in this sample of younger children with ASD, only 21% displayed poor comprehension (defined the same way). This discrepancy is best interpreted by acknowledging two factors: the age difference between samples, and the nature of the reading comprehension assessment. The children in Nation and colleague's sample were much older ( $M = 10.85$  years) than those in the present study's sample ( $M = 5.13$  years). Thus, the differences between samples could point to the possibility that reading comprehension deficits tend to develop more with age; typically, differences in reading comprehension do not develop until third grade (Rathvon, 2004).

Another possibility is that the reading comprehension assessment used by Nation and colleagues, the Neale Analysis of Reading Ability – Second Edition (NARA-II: Neale, 1997), requires different skills than the assessment used in the present study (the

WJ-III Passage Comprehension subtest). The NARA-III requires test-takers to read a passage and answer questions about the passage afterwards. The WJ-III includes two different tasks: first, the test-taker matches a pictographic representation of a word with a picture of the word, then the test-taker completes a cloze reading task where they read a passage and fill in blanks with missing words. Therefore, the NARA-II requires more expressive language ability (answering questions with phrases or complete sentences) than the WJ-III Passage Comprehension subtest (which requires only single word or short phrase answers), thus it is likely to produce more less-skilled comprehenders in a sample of children with poor oral language skills.

Regarding early literacy skills, poor comprehenders and average comprehenders differed on all AIMSweb early literacy measures, which, would suggest that poor comprehenders with ASD also tend to demonstrate poor decoding skills (whereas average comprehenders tend to demonstrate average decoding skills). This reading profile is sometimes referred to as “garden variety poor read[ing]” (Rathvon, 2004). These results are somewhat contradictory to the findings made by Nation et al. (2006), namely that word reading and non-word reading skills were no different between skilled and less-skilled comprehenders. Again, this difference could be the result of different mean ages, which would suggest that the discrepancy in decoding skills between poor and average readers is due to young age. In other words, the “hyperlexic” reading profile might not develop until after the first couple years of school. However, it is important to remember that the poor comprehenders group was much smaller than the average comprehenders group (25 vs. 95).



Regarding child characteristics, the significant differences between groups can be examined from a number of different perspectives. Firstly, poor comprehenders were significantly lower on both measures of oral language: the CCC-2, a parent report measure of oral language, and the CASL, a direct assessment of oral language. While the average comprehenders exhibited oral language skills on the CASL that were already below average (almost 1 *SD* below the mean), the poor comprehenders exhibited mean oral language skills that were even lower (about 2 *SDs* below the mean). Previous research has found that children with reading comprehension deficits (i.e., the poor comprehenders in this group) often have co-occurring language impairments (Nation et al., 2004); similarly, children with language impairments tend to have poor reading skills (Catts, Fey, Zhang & Tomblin, 1999). Similar results were found in Nation and colleagues' (2006) older sample of adolescents with ASD: "less-skilled" comprehenders were significantly lower than "skilled" comprehenders in vocabulary and oral language comprehension.

Poor comprehenders also demonstrated significantly lower IQs than their average comprehending peers in this sample. In fact, the average IQ for the poor comprehenders was more than 1 standard deviation below the mean ( $M=78.13$ ). Although Davidson and Weismer (2013) found that nonverbal cognition was a significant predictor of reading comprehension in their sample of young children with ASD, the difference in cognitive functioning between poor and average comprehenders has not been examined in the literature. Thus, these results show that there are early differences in IQ in children with

ASD, which can influence the ability of IQ to predict unique variance in reading comprehension.

Reading accuracy for the poor comprehenders was significantly lower than that of the average comprehenders. As noted above, reading accuracy is typically found to be very important in developing reading comprehension skills (Chard et al., 2002). The results of the present study are therefore supported in the literature; children who are poor comprehenders are likely to have low reading accuracy rates, since low reading accuracy typically leads to poor reading comprehension. These results provide preliminary support for the idea that improving reading accuracy might lead to improved reading comprehension in children with ASD, an idea already explored in TD children (Chard et al., 2002).

Although poor and average comprehenders differed in many ways, they exhibited similar scores on measures of social skills and problem behaviors, two characteristics central to the ASD diagnosis, as well as on autistic mannerisms, an indicator of symptom severity. This suggests that poor comprehenders and average comprehenders have similar deficits in relation to their diagnosis. This result is interesting, given that some research has suggested that social skills can predict differences in reading comprehension outcomes in adolescents with ASD (Ricketts et al., 2013). Although social skills were not significantly different for these two groups, the results did approach significance. The results of this study suggest that differences in social skills between poor comprehenders and average comprehenders might not fully emerge in early childhood; however, these differences might develop as the child progresses through school.

The results of the logistic regression showed that the predictors were not able to make significant contributions to the prediction of whether a student would be a poor or average comprehender. This suggests that there is not a consistent profile in terms of oral language skills, cognitive functioning, social skills, problem behaviors, and decoding skills that would suggest that a child with ASD would develop either poor or average comprehension. Therefore, although the results of the t-tests suggest that there are differences between poor and average comprehenders on all of these measures, these differences are not distinct enough to be able to predict group membership in terms of poor or average reading comprehension.

### **Limitations**

Though precautions were taken to ensure the results of this study were robust, there are some limitations that should be considered when examining these findings. First, of particular interest in this study was the progression of reading skills throughout the early school years using AIMSweb measures; however, the sample sizes for AIMSweb measures were small when separated by grade, therefore limiting their usefulness in analyses. However, this was noted and efforts were made to address this; for instance, WJ-III decoding measures were used for analyses that required more predictors so as to avoid power issues.

Second, recruitment for the study was ongoing and data for different participants were collected at different times, and from different schools. In order to address this, precautions were taken in certain analyses so as not to overestimate the results. For instance, when comparing performance of the sample on AIMSweb to the national

norms, the fall norm means were used so as not to overestimate poor performance by the ASD sample.

### **Implications and Future Directions**

This study provides a basis for continued research on the literacy development of young children with ASD. In order to expand on the results of the present study, some specific factors should be addressed in future research. First, it might be helpful to increase the sample size of kindergarteners and first graders. Additionally, the only skill that can be measured in pre-kindergarten (letter naming fluency) was not predictive of reading comprehension, and should not be the focus of intervention (Shinn & Shinn, 2002a). In addition to increasing the sample size of these groups, it would be important to extend these results further past the end of the school year. Thus, a longitudinal examination of the development of kindergarten and first grade decoding skills and how they predict reading comprehension for the same sample of students in third grade would be prudent, as differences and difficulties in reading comprehension typically develop more in third grade (Rathvon, 2004).

Although this study examined multiple factors that may influence the development of literacy skills in children with ASD, more research should be conducted examining additional features. For instance, previous research has suggested that home literacy, such as SES and reading at home with parents, may impact the development of reading skills in ASD (Davidson & Weismer, 2013). This would be an interesting factor to incorporate into a model similar to the one examined in this study. Additionally, another measure of ASD symptom severity, since symptom severity could potentially

affect multiple areas of schooling and literacy development, including decoding skills, reading comprehension, exposure to reading, as well as educational placement in school. This study included children with ASD who were relatively high-functioning (in terms of IQ) and may have been less varied in terms of their autistic symptomatology.

The results of this study have implications for practice. First, the reading development of young children with ASD appears to be similar to that of TD children in some ways and different in others. While some decoding skills can develop out of concert with one another in ASD children, and some decoding skills are significantly different for children with ASD, decoding skills predict reading comprehension similarly for TD children and children with ASD, alike. This suggests that performance on early literacy measures such as AIMSweb can inform later performance on reading comprehension, to some extent. However, other factors beyond decoding skills, particularly oral language skills and IQ, help predict more variance in later reading comprehension. This relationship among decoding skills, oral language, and reading comprehension is especially true for average decoders in the early years of schooling. This implies that developing a short measure of oral language skills might help educators determine which students need early intervention and which students will likely develop reading skills, thus improving the sensitivity and specificity of these early predictors of reading achievement.

In summary, the reading development of young children with ASD is both similar and dissimilar to that of young TD children and older children with ASD previously examined in the literature. Additionally, some deficits associated with ASD have an

impact on the development of reading comprehension. This study provides a basis for continued examination of the development of reading skills in young children with ASD.

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Table 1  
*Participant Characteristics*

	<i>N</i>	Min	Max	Mean	<i>SD</i>
<b>Oral Language</b>					
Parent Report (CCC-2) <sup>a</sup>	116	45	126	73.72	12.67
Child Performance (CASL) <sup>a</sup>	114	42	147	83.39	17.77
<b>IQ/Symptom Severity</b>					
Full-Scale IQ (WPPSI-III) <sup>a</sup>	119	52	123	90.48	17.18
Autistic Mannerisms (SRS) <sup>a</sup>	112	3	90	76.42	15.60
<b>Social Skills (SSIS)<sup>a</sup></b>					
Social skills	109	6	120	77.69	16.91
<b>Behavior Problems (CBCL)</b>					
Total Problems t-score	112	36	87	63.21	9.92
Internalizing Problems t-score	111	34	93	62.19	9.78
Externalizing Problems t-score	111	32	88	59.06	9.87
<b>Early Literacy (AIMSweb, Time 1)</b>					
LNF (age 4)	40	0	52	23.13	14.76
LNF (age 5)	28	0	72	37.00	17.85
LNF (age 6)	29	0	86	42.93	25.33
LSF (age 6)	34	0	54	19.74	16.55
PSF (age 6)	35	0	56	16.37	16.30
NWF (age 6)	33	0	164	39.73	47.42
R-CBM (age 7)	14	0	150	51.79	51.61
<b>R-CBM accuracy (age 7, Time 2)</b>	54	0	1	.76	.29
<b>Early Literacy (WJ-III, Time 1)</b>					
Letter-Word ID <sup>a</sup>	114	49	156	110.88	18.12
Word Attack <sup>a</sup>	96	65	158	114.00	17.72
Reading Fluency <sup>a</sup>	32	75	133	110.31	13.91
<b>Reading Comprehension (WJ-III, Time 2)</b>					
Passage Comprehension	120	39	146	97.88	18.25

*Note.* *SD* = standard deviation; CCC-2 = Child Communication Checklist – Second Edition; CASL = Comprehensive Assessment of Spoken Language; WPPSI-III = Wechsler Preschool and Primary Scale of Intelligence – Third Edition; SRS = Social Responsiveness Scale; SSIS = Social Skills Improvement System; CBCL = Child Behavior Checklist; LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading-curriculum based measurement; WJ-III = Woodcock Johnson Tests of Achievement – Third Edition.

<sup>a</sup> Standard score with a mean of 100

Table 2  
*Comparison of Means on AIMSweb*

	<b>Population Mean (SD)</b>	<b>Sample Mean (SD)</b>	<b>t value</b>
<b>LNF (age 4)</b>	11 (13)	23.13 (14.76)	5.20***
<b>LNF (age 5)</b>	22 (17)	37.00 (17.85)	4.45***
<b>LNF (age 6)</b>	46 (16)	42.93 (25.33)	-.65
<b>LSF</b>	31 (15)	19.74 (16.55)	-3.97***
<b>PSF</b>	39 (17)	16.37 (16.30)	-8.21***
<b>NWF</b>	39 (25)	39.73 (47.42)	.09
<b>R-CBM</b>	64 (37)	51.79 (51.61)	-.89

*Note.* SD = standard deviation; LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading-curriculum based measurement.

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Table 3  
*Percentage of Students Meeting Benchmark*

	<b>Benchmark</b>	<b>Strategic</b>	<b>Intensive</b>
<b>LNF</b>	71.4%	17.3%	11.2%
<b>LSF</b>	35.3%	11.8%	52.9%
<b>PSF</b>	17.1%	14.3%	68.6%
<b>NWF</b>	40.6%	18.8%	40.6%
<b>R-CBM</b>	33.3%	26.7%	40.0%

*Note.* LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading-curriculum based measurement.

Table 4

*Correlations between AIMSweb and Child Characteristics*

	1	2	3	4	5	6	7	8	9	10	11	12	13
<b>1. LNF</b>	1												
<b>2. LSF</b>	.61**	1											
<b>3. PSF</b>	.50**	.73**	1										
<b>4. NWF</b>	.62**	.53**	.53**	1									
<b>5. R-CBM</b>	-	-	-	-	1								
<b>6. CCC-2</b>	.08	.39*	.42*	.42*	.19	1							
<b>7. CASL</b>	.35**	.59**	.72**	.65**	.47	.36**	1						
<b>8. WPPSI</b>	.36**	.51**	.62**	.60**	.17	.24**	.70**	1					
<b>9. CBCL Total</b>	-.04	.28	.39*	.26	-.03	-.51**	-.06	-.02	1				
<b>10. CBCL Int.</b>	.03	.24	.35*	.04	.23	-.44**	.07	.10	.77**	1			
<b>11. CBCL Ext.</b>	-.02	.33	.41*	.39*	-.17	-.42**	-.09	-.03	.88**	.60**	1		
<b>12. SSIS</b>	.15	.29	.22	.11	-.06	.38**	.24*	.37**	-.45**	-.21*	-.36**	1	
<b>13. SRS Aut.</b>	.00	.11	.15	.14	-.39	-.45**	-.12	-.18	.46**	.33**	.42**	-.24*	1

*Note.* LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading-curriculum based measurement; CCC-2 = Child Communication Checklist – Second Edition; CASL = Comprehensive Assessment of Spoken Language; WPPSI-III = Wechsler Preschool and Primary Scale of Intelligence – Third Edition; CBCL Total = Child Behavior Checklist, total problems t-score; CBCL Int. = Child Behavior Checklist, internalizing problems t-score; CBCL Ext. = Child Behavior Checklist, externalizing problems t-score; SSIS = Social Skills Improvement System; SRS = Social Responsiveness Scale.

\* $p < .05$ , \*\*  $p < .01$

Table 5  
*Correlations between AIMSweb and WJ-III Decoding Measures*

	1	2	3	4	5	6	7	8
<b>1. LNF</b>	1							
<b>2. LSF</b>	.61**	1						
<b>3. PSF</b>	.50**	.73**	1					
<b>4. NWF</b>	.62**	.53**	.53**	1				
<b>5. R-CBM</b>	-	-	-	-	1			
<b>6. Letter Word</b>	.54**	.56**	.49**	.76**	.79**	1		
<b>7. Word Attack</b>	.63**	.55**	.53**	.71**	.68**	.80**	1	
<b>8. Reading</b>	.61**	.49*	.16	.72**	.78**	.75**	.61**	1

*Note.* LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading-curriculum based measurement.  
 \* $p < .05$ , \*\*  $p < .01$

Table 6  
*Performance on AIMSweb Predicting Reading Comprehension*

		<b>B</b>	<b>Std. Error of B</b>	<b>Beta</b>	<b>Adjusted R<sup>2</sup></b>
<b>Pre-kindergarten</b>	Constant	73.28	17.06		
	LNF	.25	.15	.27	.07
<b>Kindergarten</b>	Constant	75.52	19.97		
	LNF	.27	.17	.30	.09
<b>First Grade</b>	Constant	22.99	12.34		
	NWF	.50	.08	.73***	.54
<b>Second Grade</b>	Constant	43.06	19.30		
	R-CBM	.47	.20	.57*	.32

*Note.* LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading-curriculum based measurement.

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Table 7  
*Model using Decoding and Child Characteristics to Predict Reading Comprehension*

<b>Step</b>	<b>Variable</b>	<b><i>R</i><sup>2</sup></b>	<b><i>F</i> change</b>	<b><i>p</i></b>	<b><i>β</i></b>	<b><i>p</i></b>
1	WJ-III Letter-Word ID	.31	49.50	<.001	.44	<.001
2	CASL	.09	15.68	<.001	.17	.12
3	WPPSI-III IQ	.02	4.25	<.05	.21	<.05

*Note.* WJ-III = Woodcock Johnson Tests of Achievement – Third Edition; CASL = Comprehensive Assessment of Spoken Language; WPPSI-III IQ = Intellectual quotient on the abbreviated Wechsler Preschool and Primary Scale of Intelligence – Third Edition.

Table 8  
*Predictive Ability of Oral Language for Poor versus Average Decoders*

<b>Model (Decoding)</b>	<b>Step</b>	<b>Variable</b>	<b><i>R</i><sup>2</sup> change</b>	<b><i>F</i> change</b>	<b><i>p</i></b>	<b><i>β</i></b>	<b><i>p</i></b>
1. Poor	1	WJ-III Letter-Word ID	.30	6.77	<.05	.55	<.05
2. Average	1	WJ-III Letter-Word ID	.23	27.44	<.001	.38	<.001
	2	CASL	.08	10.93	<.001	.30	<.001

*Note.* WJ-III = Woodcock Johnson Tests of Achievement – Third Edition; CASL = Comprehensive Assessment of Spoken Language.



Table 9  
*Differences in Poor versus Average Comprehenders*

	<i>Poor Comprehenders</i>			<i>Average Comprehenders</i>			<b>t value</b>
	<i>N</i>	<b>Mean (SD)</b>	<b>Range</b>	<i>N</i>	<b>Mean (SD)</b>	<b>Range</b>	
<b>Child Age</b>	25	5.4 (1.08)	4-7	95	5.06 (.98)	4-7	1.36
<b>Oral Language</b>							
CCC-2 <sup>a</sup>	23	68.17 (8.92)	52-90	93	75.09 (13.22)	45-126	2.39*
CASL <sup>a</sup>	24	70.54 (14.75)	42-100	90	86.82 (16.98)	52-147	4.28***
<b>IQ/Symptoms</b>							
WPPSI-III IQ <sup>a</sup>	24	78.13 (18.28)	52-112	95	93.60 (15.49)	55-123	4.21***
Autistic Mannerisms <sup>b</sup>	24	80.25 (11.97)	3-90	88	75.38 (16.36)	3-90	1.36
<b>Social Skills<sup>a</sup></b>	23	71.83 (14.36)	40-98	86	80.30 (15.40)	42-120	1.89
<b>Problem Bx</b>							
Internalizing <sup>b</sup>	23	61.83 (9.19)	45-80	88	62.28 (9.98)	34-93	.20
Externalizing <sup>b</sup>	23	61.09 (7.45)	47-79	88	58.53 (10.39)	32-88	-1.11
Total <sup>b</sup>	23	65.17 (7.72)	50-81	89	62.70 (10.39)	36-87	-1.07
<b>Decoding Skills<sup>c</sup></b>							
LNF	14	20.21 (16.14)	0-48	50	32.28 (18.55)	0-84	2.03*
LSF	8	10.25 (9.48)	0-24	26	22.65 (17.29)	0-54	2.60*
PSF	8	3.13 (5.08)	0-15	27	20.30 (16.45)	0-56	4.72***
NWF	8	4.00 (6.39)	0-18	25	51.16 (49.24)	0-164	4.67***
<b>Reading Skills</b>							
Fluency <sup>c</sup>	4	26.75 (37.01)	0-79	10	61.80 (54.78)	4-150	1.16
Accuracy	11	41% (32.67)	0-100%	43	85% (19.71)	7-100%	4.28***

*Note.* SD = standard deviation; CCC-2 = Child Communication Checklist – Second Edition; CASL = Comprehensive Assessment of Spoken Language; WPPSI-III IQ = Intellectual quotient on the abbreviated Wechsler Preschool and Primary Scale of Intelligence – Third Edition; LNF = letter naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency.

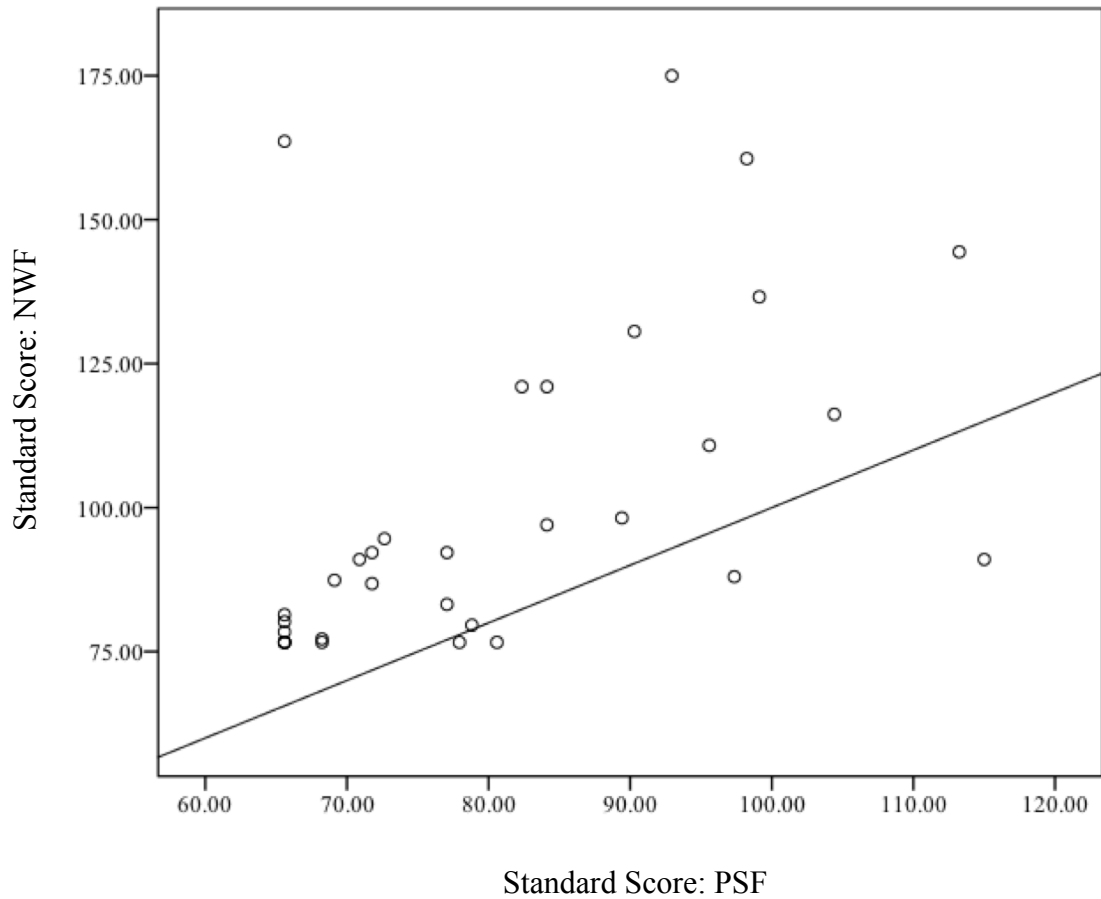
<sup>a</sup> Standard score with a mean of 100, <sup>b</sup> t-score, <sup>c</sup> raw score.

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

Table 10  
*Predicting Poor versus Average Comprehension*

		95% CI for Odds Ratio		
	<i>B</i> (SE)	Lower	Odds Ratio	Upper
<b>Constant</b>	-6.91 (3.43)			
<b>CASL</b>	.01 (.01)	.99	1.01	1.03
<b>WPPSI-III IQ</b>	.04 (.02)	1.00	1.04	1.09
<b>SSIS</b>	.00 (.02)	.97	1.00	1.04
<b>CBCL Ext.</b>	-.02 (.03)	.93	.99	1.05
<b>WJ-III Letter-Word ID</b>	.04 (.02)	1.00	1.04	1.08

*Note.* CASL = Comprehensive Assessment of Spoken Language standard score; WPPSI-III IQ = Intellectual quotient on the Wechsler Preschool and Primary Scale of Intelligence – Third Edition; SSIS = Social Skills Improvement System, social skills subscale standard score; CBCL Ext. = Child Behavior Checklist, externalizing problems t-score; WJ-III = Woodcock Johnson Tests of Achievement – Third Edition.



*Figure 1.* Scatter plot of performance on PSF (standard score) versus performance on NWF (standard score) for first grade participants ( $n = 33$ ). The line indicates a perfect relationship between the PSF and NWF, where performance on the two measures is equivalent.