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Predicting Reading Comprehension in Young Children With Autism Spectrum Disorder

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Relationships between early literacy measures (i.e., curriculum-based measurement) and advanced literacy measures (i.e., reading comprehension) were examined in young children with autism spectrum disorders (ASDs). Participants in this study were 167 children between the ages of 4 and 7 years (M = 5 years 8 months), who were assessed at 2 time points during 1 school year. Results indicated that, compared to other measures of early literacy skills, curriculum-based measurements (CBMs) accurately assessed skills in students with ASD. Furthermore, early literacy skills predicted reading comprehension approximately six months later in this sample. The reading development of children with ASD compared to typically developing children appears to be similar in the predictive capacity of decoding skills on later reading skills and dissimilar in the variability and range of skills. CBM tools can provide educators with information about the early reading skills of children with ASD to help address reading and language difficulties seen in this population.

Impact and Implications

This article examines the relationship between brief early literacy measures (i.e., curriculum-based measurements) and standardized measures of reading comprehension in a young sample of children with autism spectrum disorder (ASD). The results suggest that these short measures of early reading skills accurately predicted later reading comprehension in this sample. These measures can provide critical information about the early reading skills of children with ASD and can be used to help address common reading difficulties seen in this population.

Keywords: autism, ASD, reading comprehension, reading development, curriculum-based measurement

Children with an autism spectrum disorder (ASD) typically experience social and communication deficits that have an impact on their educational and social success in school, including their reading skills. Whereas some research has shown that children with ASD display above-average decoding skills and lower than expected reading comprehension skills (Grigorenko et al., 2002; Newman et al., 2007), other studies have suggested much more variability in decoding skills in this population (Nation, Clarke, Wright, & Williams, 2006; Norbury & Nation, 2011). These differences across studies indicate that children with ASD may experience particular challenges in early reading development; moreover, they suggest the need for further investigation to determine who may develop adequate versus poor reading comprehension skills and to what extent this is a function of differences in decoding skills.

Typical Reading Development and Its Measurement

The simple view of reading, which suggests that reading comprehension is the product of decoding skills and linguistic comprehension, is the standard, research-supported, theoretical model for reading development (Gough & Tunmer, 1986). This model suggests that early reading skills, referred to as "decoding skills" by Gough and Tunmer (1986, p. 6–7; i.e., phonological awareness and phonics), and language skills (i.e., linguistic comprehension) have a multiplicative effect on reading comprehension development. Further, research in typically developing (TD) children has demonstrated that decoding and fluency (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Good, Simmons, & Kame'enui, 2001) and language skills (Bishop & Adams, 1990; Nation, Clarke, Marshall, & Durand, 2004; Nation & Snowling, 2004) predict reading compre-

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hension, in support of this model. These predictive findings allow schools to effectively identify students who may benefit from early intervention efforts, because they suggest that students with early decoding or fluency difficulties based on reading skill measures are likely to need support to promote later success in reading comprehension.

Reading Development Among Children With ASD

Although these relationships are clear in TD children, there is limited research on reading development and the path to reading comprehension in ASD, though several studies have examined this topic (Davidson & Ellis Weismer, 2014; Nation et al., 2006; Norbury & Nation, 2011; Ricketts, Jones, Happé, & Charman, 2013; Smith Gabig, 2010). Overall, although reading development in students with ASD appears to be similar to that in TD students (Brown, Oram-Cardy, & Johnson, 2013; Nation et al., 2006), there is little evidence to suggest that one can predict later reading comprehension based on brief early measures of reading as is done for TD students in schools, because few studies have attempted to validate such tools for this purpose.

Although children with ASD may display levels of decoding skills similar to those of TD children, their reading comprehension skills are substantially lower but similarly variable (Davidson & Ellis Weismer, 2014; McIntyre et al., 2017; Nation et al., 2006; Solari et al., 2017). Recent studies with children ages 8−6 found that although school-age children with ASD were no different from TD students in their sight word reading (when controlling IQ), they were significantly different in other components of reading, including reading comprehension (McIntyre et al., 2017; Solari et al., 2017). Further, Nation and colleagues (2006) found that in their sample of 6- to 15-year-old students with ASD, 65% showed reading comprehension skills at least 1 *SD* below the mean, and 38% showed reading comprehension skills 2 *SD*s below the mean. Comparably, in Ricketts and colleagues' (2013) study of adolescents with ASD, 60% showed reading comprehension skills at least 1 *SD* below the mean, and 32% showed reading comprehension skills 2 *SD*s below the mean.

Both studies also examined forms of decoding, whether through measures of single word recognition or nonword decoding (Nation et al., 2006; Ricketts et al., 2013). Although some deficits were noted in Ricketts and colleagues' (2013) sample (i.e., 45% of students performed 1 *SD* below the mean), they were not as widespread as the deficits in reading comprehension; further, Nation and colleagues (2006) reported mean scores within the average range for word recognition and nonword reading. Thus, some students with ASD may not develop reading comprehension skills at a level commensurate with their decoding skills.

ASD Severity and Reading Skills

Efforts to implement school-based services that are preventative and provide early intervention for reading deficits may be complicated by the potentially incongruent reading profiles of students with ASD. Given the unique nature of ASD and its associated deficits in social communication, it is possible that performance on reading measures may be different depending on the level of autism symptomology. In fact, students with fewer ASD-related symptoms (e.g., poor or delayed language, poor social communication) tend to do better on reading measures, after controlling for IQ (Estes, Rivera, Bryan, Cali, & Dawson, 2011; Norbury & Nation, 2011); also, fewer ASD-related symptoms have been shown to predict higher reading comprehension (Davidson & Ellis Weismer, 2014; McIntyre et al., 2017; Ricketts et al., 2013). Thus, it is possible that performance on measures of various reading skills may be different for students with fewer ASD symptoms, perhaps due in part to a greater capacity for maintaining focus and interest in the task. It could also be attributed to greater higher order social and cognitive skills that are often required for managing information intake during reading tasks (e.g., verbal efficiency; Perfetti, 1985) and the possibility that the same problems that lead to higher order language difficulties may lead to reading comprehension difficulties (McIntyre et al., 2017).

Measurement of Reading Skills

Measures of reading often used in schools include curriculum-based measurements (CBMs), which are brief and discrete and can be used to assess early reading skills at one time and predict later reading achievement based on meeting a cutoff score that indicates level of risk (Good et al., 2001). AIMSweb (Shinn & Shinn, 2002a, 2002b) is a common, valid, and reliable CBM related to longer, norm-referenced reading measures, although this is not often studied in children with ASD. CBM tools differ from other measures of reading skills; they are standardized, use different probes dependent on reading skill and grade, and are timed (usually 1 min). CBMs are criterion-referenced, whereas others are typically norm-referenced.

However, mirroring the lack of research on reading development in ASD, although criterion-referenced CBM measures are increasingly being used in schools, their use is not often examined in children with developmental delays, such as ASD. A recent study used DIBELS Oral Reading Fluency, another CBM, with children ages 8−16 and found significant differences between students with ASD and those who were typically developing (Solari et al., 2017). Their limited use is problematic because CBM tools must be validated for use with this population in research before they are used to make educational decisions in practice, in accordance with the test standards recommended by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education (1999). Further, it is particularly important to understand whether there are any differences in performance on these tasks as a function of ASD severity to provide more specific recommendations for their use.

Research on the use of CBM tools to predict reading outcomes for students with ASD has implications for school psychologists, who may use data from CBM measures to determine who may need reading intervention. Potential deficits in reading skills may be missed if CBM tools measure reading development differently for students with ASD, compared to typically developing students, who are measured through national norms. Additionally, although some research has examined how decoding and reading comprehension vary by level of ASD severity (McIntyre et al., 2017), there is no research to suggest how young children with different autism severity levels perform on CBMs.

Rationale for the Current Study

Extant literature pertaining to the association between decoding skills and reading comprehension in children with ASD is limited but growing. First, timed CBM measures have rarely been empirically studied with this population, except with older children (Solari et al., 2017). There is reason to expect these measures might be particularly well suited for younger children with ASD, given that, relative to many other assessments, CBMs have minimal verbal requirements. Further, given the potentially limited test-taking skills of students with ASD, including difficulty sitting still and paying attention for extended periods of time, the brevity of CBMs may be advantageous (Paynter, 2015). Conversely, the limitations associated with timed measures, such as not pausing the timer once it is started, can produce challenges if the child demonstrates disruptive behaviors, such as self-stimulation or task avoidance. Second, few studies have examined reading ability in a well-characterized, relatively large sample of young children with ASD.

Thus, the goals of this study of a group of high-functioning young children with ASD were as follows: to provide support for the use of CBM tools and to examine the predictive ability of decoding skills (measured with CBMs) at the beginning of the school year on reading comprehension (measured with a norm-referenced measure) at the end of the school year. Toward that end, we raised the following questions: (a) How does the performance of young children with ASD compare to national norms on AIMSweb, a popular CBM of benchmark decoding skills? (b) What is the relationship between performance on AIMSweb and performance on the Woodcock-Johnson III Tests of Achievement, a norm-referenced, standardized measure of decoding? (c) To what extent do AIMSweb measures predict performance on standardized measures of reading comprehension for students with ASD? (d) To what extent are there differences in performance on CBMs between two groups of students with different levels of ASD symptoms?

Method

Participants

Participants were children and parents in a longitudinal study on the transition to school for young children with ASD, and they were recruited through multiple means (e.g., ASD screening center, schools, and service providers). The children recruited were between prekindergarten and second grade (ages 4−7), with a mean age of 5.7 at the time of recruitment. Children eligible for the study were between the ages of 4 and 7 at the initial visit, with an IQ of 50 or above, with some oral language skills, and with a diagnosis of ASD (as determined through procedures described later). Consistent with the ASD population, 80.7% of the sample recruited was male. Child race was based on an open-ended parent-report item later aggregated into categories; the majority of participants were non-Latino White (57.0%), followed by bi- or multiracial children (19.4%), Latino (10.3%), Asian American (6.7%), African American or Black (2.4%), and other (4.2%). Parent ability to speak and complete measures in English was also a requirement for participation.

A total of 167 of the original 186 children continued through all three assessment visits that composed this study, resulting in an attrition rate of 10.2%. The means of the group retained for the study and the group that dropped out were compared (e.g., on IQ, language, and other dependent variables), and there were no differences in any key variables. Notably, the final sample of children had a mean IQ in the average range ($M = 88.45$, although about 15% were below 70, the cutoff for intellectual disability) but with autism symptom severity in the severe range, on average.

Measures

Autism Diagnostic Observation Schedule (ADOS). The ADOS is considered the gold standard in autism assessment and has strong reliability and validity (Lord, Rutter, DiLavore, & Risi, 2008). To assess symptom severity, we converted ADOS total scores to severity scores using Gotham, Pickles, and Lord's (2009) standardized scores. Based on their guidelines, severity scores of 2−5 were considered mild−moderate and scores of 6 and above were deemed severe. In this study, two groups (mild−moderate and severe) were used for severity analyses.

Wechsler Preschool and Primary Scales of Intelligence—Third Edition (WPPSI–III). An abbreviated version of the WPPSI–III (Wechsler, 2002) was used. The three-subtest version (including Block Design, Vocabulary, and Matrix Reasoning) has established reliability ($r = .95$) and high predictive validity ($r = .95$) in its estimation of cognitive skills (Sattler & Dumont, 2004). Mean performance on the WPPSI–III was in the low average range ($M = 88.45$, $SD = 17.70$).

Comprehensive Assessment of Spoken Language (CASL). Language skills were measured by the Pragmatic Judgment, Basic Skills, and Syntax Construction subtests of the CASL (Carrow-Woolfolk, 2008). The CASL subtests have high reliability (rs $= .64−.94$) and established criterion validity, as per correlations with other oral language measures (e.g., the Peabody Picture Vocabulary Test) reported in the technical manual (Carrow-Woolfolk, 2008). Mean performance was in the below-average range ($M = 81.97$, $SD = 17.39$).

AIMSweb. Participants' early literacy skills were assessed using AIMSweb (Shinn & Shinn, 2002a, 2002b), a set of curriculum-based measurement (CBM) measures. These can be used as criterion-referenced measures to predict later reading success but also have validated norms. Letter-naming fluency (LNF) was used for preschoolers, kindergarteners, and first graders. First graders were also assessed with letter sound fluency (LSF), phoneme segmentation fluency (PSF), and nonsense word fluency (NWF). On both LNF and LSF, students are given a page of letters and are asked to provide as many letter names or sounds, respectively, as they can. PSF is administered entirely orally; students are asked to provide all of the sounds in given words (e.g., "/c/ /a/ /t/" for *cat*). On NWF, students are given a page of nonsense words (i.e., fake words with the same structure as real English words) and are asked to sound them out. Raw scores indicated the number of letter names or sounds the child provided in 1 min. AIMSweb measures were given without accommodations, just as they are given in school settings, to ensure generalizability. Timing began when the student attended to the probe, but the clock was not stopped if the student lost focus during administration. This did occur in some, but not all, cases. Additionally, reading CBM (R-CBM) was used for second graders, and the median number of words read correctly of three passages was recorded. All of these measures take 1 min to complete; because three R-CBM probes are given, this measure takes 3 min to complete.

Performance on the AIMSweb can be analyzed by determining whether participants reach a certain criterion indicating future success (Shinn & Shinn, 2002a, 2002b); hence, it is referred to as a criterion-referenced measure. These criteria include benchmark (described in the manual as 80% likelihood of later success), strategic (50%–80% likelihood), and intensive (less than 50% likelihood). Interrater reliability was calculated for 20% of cases for each probe to ensure fidelity of implementation across sites by dividing agreements by total agreements plus disagreements and multiplying by 100. Overall reliability was 95.4%. R-CBM passage reliability coefficients are .90 and above across reliability estimates, and passages are correlated with future reading achievement (NCS Pearson, 2012). Measures have adequate reliability (rs = .94−.99) and validity (e.g., criterion validity between .60 and .72; NCS Pearson, 2012) coefficients.

Woodcock-Johnson III Tests of Achievement (WJ-III). Subtests used from the WJ-III (Woodcock, McGrew, & Mather, 2001) included Letter−Word Identification (in which the child identifies letters and words), Word Attack (in which the child sounds out nonwords), Reading Fluency (in which the child reads through short statements for 3 min and determines whether each statement is true or false), and Passage Comprehension (in which the child performs multiple tasks, including matching words and phrases to pictures, and a cloze reading task, on which the child fills in blanks with the appropriate words in brief passages).

The WJ-III is a reliable and valid measure of reading achievement, with high test–retest reliability coefficients for subtests used from .88 to .94, as provided in the technical manual. The WJ-III is also highly correlated with other measures of reading skills (e.g., Wechsler Individual Achievement Test - Third Edition, Kaufman Test of Educational Achievement, Second Edition).

Procedures

Institutional Review Board (IRB) approval was obtained for all study activities. Participants were recruited from communities in Southern California and the greater Boston area through IRB-approved flyers in school- and university-based settings. Parents of children who were diagnosed with ASD in a school or clinic were invited in to confirm ASD status, IQ, and language abilities. Participants completed multiple visits, of which three were used in the current study: an eligibility visit, a Time 1 visit, and a Time 2 visit.

The eligibility visit took place the summer before, or very early in, fall of the school year. All children were assessed at this time with the ADOS to verify their diagnosis by assessors who had achieved reliability on the ADOS. During this visit, the WPPSI–III and CASL were also completed.

The first assessment visit (Time 1) occurred in the fall of the school year, when early literacy skills were assessed with AIMSweb measures, dependent on the child's grade, as well as subtests on the norm-referenced WJ-III, including Letter–Word Identification, Word Attack, and Reading Fluency. The second visit (Time 2) took place in the spring of that same school year, when reading comprehension was assessed with Passage Comprehension on the WJ-III.

Results

The descriptive statistics for the sample are provided in Table 1. For all analyses except those addressing the first research question, children's scores on AIMSweb tests of early literacy skills were first converted to z scores to standardize the raw AIMSweb scores. Raw AIMSweb scores were converted to z scores by subtracting the normative mean raw score 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. Effect size estimates are provided where relevant, with an interpretation of their size as per Cohen's (1988) recommendations.

Comparing AIMSweb Scores to National Norms

To address the first question, how this sample of high-functioning children with ASD compared to national norms on AIMSweb benchmark measures, we ran one-sample t tests on each of the measures at each grade (LNF in prekindergarten; 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 (see Table 2). Fall grade-level norms were used as a comparison.

There were differences in performance on AIMSweb measures between children with ASD in the sample and the national norms. First, the results of the t test comparing prekindergarten (n = 64) children on LNF indicated significant differences between the ASD sample mean and the national norm, $t(63) = 6.22$, $p < .001$, with a medium effect size (d = .78). These differences were maintained in kindergarten (n = 49) on LNF, $t(48) = 4.72$, $p < .001$ (medium effect, d = .67), but not in first grade (n = 39), $t(38) = -.03$, $p = .98$ (negligible effect, d = .00). The ASD sample means on LNF in prekindergarten and kindergarten were both significantly higher than the AIMSweb normative means. Differences emerged for first graders on LSF (n = 39), $t(38) = -3.84$, $p < .001$ (medium effect, $d = -.61$); children in the ASD sample performed significantly lower than did children in the normative group. The same was evident for first graders on PSF (n = 39), $t(38) = -7.91$, $p < .001$ (large effect, $d = -1.27$). However, no differences emerged for first graders on NWF (n = 39), $t(38) = .27$, $p = .79$ (negligible effect, d = .04), or for second graders on R-CBM (n = 15), $t(14) = -.21$, $p = .84$ (negligible effect, $d = -.05$).

Because AIMSweb is a criterion-referenced measure, performance can be examined by determining whether students reached certain benchmark scores. The goal is for 80% of children to score in the benchmark range, 15% in the strategic range, and 5% in the intensive range (Shinn & Shinn, 2002a, 2002b). Whereas 78.4% of kindergarten and first-grade students in this study performed at or above their grade-appropriate benchmark on LNF (cutoff scores are not provided by AIMSweb for students in prekindergarten), only 41.0%, 17.9%, 51.3%, and 46.7% of students performed at or above benchmark on LSF, PSF, NWF, and R-CBM, respectively (see Table 3). These results suggest notable variability in skills in this high-functioning sample.

Table 1
Mean Language, IQ, and Academic Skills for this Sample of High-functioning Students with ASD

Measure	*n*	Min	Max	*M*	*SD*
Oral language					
Child Performance (CASL)[a]	167	42	130	81.97	17.39
IQ−symptom severity					
Full-scale IQ (WPPSI–III)[a]	167	46	139	88.45	17.70
Autism symptoms (SRS)[b]	167	46	90	79.59	10.99
Autism severity (ADOS)	167	2.00	10.00		
Early literacy (AIMSweb, Time 1)					
LNF (Prekindergarten)	64	0	53	21.91	14.03
LNF (Kindergarten)	49	6	72	33.80	17.50
LNF (Grade 1)	39	0	86	45.90	22.16
LSF (Grade 1)	39	0	54	21.33	15.73
PSF (Grade 1)	39	0	57	17.36	17.08
NWF (Grade 1)	39	0	164	40.85	42.49
R-CBM (Grade 2)	15	0	150	61.13	54.25
Early literacy (WJ-III, Time 1)					
Letter−Word Identification[a]	167	49	159	111.77	18.84
Word Attack[a]	134	65	159	115.08	17.57
Reading Fluency[a,c]	46	71	133	107.24	17.52
Reading Comprehension (WJ-III, Time 2)					
Passage Comprehension	167	42	146	98.06	17.42

Note. Min = minimum; Max = maximum; CASL = Comprehensive Assessment of Spoken Language; WPPSI–III = Wechsler Preschool and Primary Scale of Intelligence—Third Edition; SRS = Social Responsiveness Scale; ADOS = Autism Diagnostic Observation Schedule; 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.
[a] Standard score with a mean of 100. [b] T score with a mean of 60. [c] Completed by a subsample of 46 children, given that many children at this age did not have the baseline reading skills necessary to complete it.

Relationships Among AIMSweb Measures and WJ-III Measures

To address the second research question, we ran correlations between AIMSweb and WJ-III literacy measures to examine relationships between tools that measure the same or similar skills. The results indicated that AIMSweb measures and their WJ-III equivalents were highly correlated in this sample (see Table 4). The WJ-III Letter−Word Identification subtest was correlated with all AIMSweb early literacy measures but was most highly correlated with NWF, a nonword reading task measuring phonics, $r(37) = .68$, $p < .01$. The WJ-III Word Attack subtest was similarly correlated with all AIMSweb early literacy measures and was also most highly correlated with NWF, $r(37) = .66$, $p < .01$. The WJ-III Reading Fluency subtest was correlated with all AIMSweb measures; as expected, it was correlated with AIMSweb R-CBM, $r(13) = .72$, $p < .01$. These analyses provide initial support for the construct validity of CBM measures used with high-functioning students on the autism spectrum, in addition to more in-depth studies of their validity.

Decoding Skills Predicting Reading Comprehension

To address the third question, determining the amount of variance in reading comprehension accounted for by AIMSweb measures, we ran one regression analysis for each grade level (prekin-

Table 2
Comparison of Normative Means to Sample Means on AIMSweb Curriculum-based Measurement at Time 1

Measure	Normative mean (*SD*)	ASD sample mean (*SD*)	*t*	Cohen's *d*
LNF (Prekindergarten)	11 (13)	21.91 (14.03)	6.22***	.78
LNF (Kindergarten)	22 (17)	33.80 (17.50)	4.72***	.67
LNF (Grade 1)	46 (16)	45.90 (22.16)	−.03	−.00
LSF (Grade 1)	31 (15)	21.33 (15.73)	−3.84***	−.61
PSF (Grade 1)	39 (17)	17.36 (17.08)	−7.91***	−1.27
NWF (Grade 1)	39 (25)	40.85 (42.49)	.27	.04
R-CBM (Grade 2)	64 (37)	61.13 (54.25)	−.21	−.05

Note. ASD = autism spectrum disorder; LNF = letter-naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency; R-CBM = reading curriculum-based measurement.
*** $p < .001$.

Table 3
Percentage of Students in the Sample Meeting Benchmark on AIMSweb Curriculum-based Measurement at Time 1

Measure	Benchmark	Strategic	Intensive
LNF (Kindergarten and Grade 1)	78.4	10.2	11.4
LSF (Grade 1)	41.0	23.1	35.9
PSF (Grade 1)	17.9	20.5	61.5
NWF (Grade 1)	51.3	23.1	25.6
R-CBM (Grade 2)	46.7	20.0	33.3

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

dergarten, kindergarten, first grade, and second grade) using the grade-appropriate AIMSweb Time 1 measures as predictors. WJ-III Passage Comprehension, measured at Time 2, was the outcome measure of reading comprehension for all regressions. Power analyses were run, and except where noted (among second-grade-specific analyses), power was sufficient to detect a medium effect. All assumptions were met for each regression analysis.

The first regression included LNF as the predictor for prekindergarten students (n = 64; M = .84, SD = 1.08). The results of the regression indicated that LNF in prekindergarten (β = .28, $p <$ .05) accounted for a small, but significant, amount of variance in reading comprehension (R^2 = .08), $F(1, 62) = 5.28$, $p < .05$, predicting 8% of variance in the outcome. LNF in kindergarten (n = 49; M = .74, SD = 1.09) was predictive of reading comprehension (β = .46, $p < .01$), predicting 21% of the variance in the outcome (R^2 = .21), $F(1, 47) = 12.50$, $p < .01$.

A hierarchical multiple regression was run for first-grade students, age 6 (n = 40), using all first-grade AIMSweb measures. LNF (M = −.02, SD = 1.37), LSF (M = −.64, SD = 1.04), PSF (M = −1.28, SD = .99), and NWF (M = .04, SD = 1.69) were entered into the hierarchical regression predicting reading comprehension (M = 96.43, SD = 16.22). Due to prior research regarding the correlations among measures (Burke, Hagan-Burke, Kwok, & Parker, 2009; Riedel, 2007) and correlations among variables in this study, NWF was entered at Step 1, PSF at Step 2, LSF at Step 3, and LNF at Step 4. In the final model, NWF (β = .58, $p < .001$) and PSF (β = .29, $p < .05$) significantly predicted reading comprehension and accounted for 59% of the variance in reading comprehension (R^2 = .59), $F(2, 37) = 26.88$, $p < .001$.

For second graders (n = 15), R-CBM (M = −.08, SD = 1.47) was used in the regression to predict reading comprehension for 15 participants (M = 89.20, SD = 17.26); power was reduced (.79) due to small sample size. R-CBM was nonetheless a significant predictor of reading comprehension (β = .61, $p < .05$), predicting 37% of the variance in reading comprehension (R^2 = .37), $F(1, 13) = 7.63$, $p <$ .05, thus supporting the predictive validity of these measures.

These analyses were run again, controlling for IQ, given the methods of some previous literature (Estes et al., 2011; Norbury & Nation, 2011). When IQ was entered, LNF was no longer predictive of WJ-III passage comprehension in prekindergarteners or kindergarteners. Conversely, for first graders, NWF was retained (β = .54, $p < .001$) in the model after controlling for IQ (β = .30, $p < .05$), predicting a total of 58% of the variance in reading comprehension (R^2 = .58), $F(2, 37) = 25.96$, $p < .001$, which was not an improvement on the original model. For second graders, R-CBM was also retained (β = .40, $p < .05$) in the model after controlling for IQ (β = .64, $p < .01$), predicting a total of 73% of the variance in reading comprehension (R^2 = .73), $F(2, 12)$ = 16.55, $p < .001$.

Autism Severity and CBM Performance

To address the fourth question related to autism severity and performance on AIMSweb measures, we ran separate analyses for each AIMSweb measure based on ADOS severity score (i.e., mild−moderate = 2−5; severe = 6 and up; see Table 5). ADOS severity group was the independent variable, and performance on AIMSweb measures (LNF, LSF, PSF, NWF, or R-CBM) was the dependent variable in independent-samples t tests. AIMSweb means were not different between autism symptom severity groups for LNF in prekindergarten, $t(62) = .21$, $p = .84$ (negligible effect, $d = .07$), or kindergarten, $t(62) = .21$, $p = .84$ (negligible effect,

Table 4
Correlations Between AIMSweb and WJ-III Decoding Measures at Time 1 and WJ-III Passage Comprehension at Time 2

Measure	1	2	3	4	5	6	7	8
1. LNF								
2. LSF	.53**							
3. PSF	.50**	.70**						
4. NWF	.58**	.45**	.52**					
5. R-CBM	—	—	—	—				
6. Letter−Word Identification	.44**	.35*	.37*	.68**	.83**			
7. Word Attack	.50**	.45**	.42**	.66**	.65**	.80**		
8. Reading Fluency	.64**	.53**	.43*	.71**	.72**	.82**	.70**	
9. Passage Comprehension	.42**	.49**	.61**	.73**	.61*	.62**	.63**	.83**

Note. The ns for each measure varied due to different ages of participants (LNF: 152, LSF: 39, PSF: 39, NWF: 39, R-CBM: 15, Letter−Word Identification: 167, Word Attack: 134, Reading Fluency: 46, Passage Comprehension: 167). Dashes in row 5 indicate that these data were not obtained as each of the AIMSweb measures were collected with a different subsample, given age and grade. WJ-III = Woodcock-Johnson III Tests of Achievement; 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 5
Performance on AIMSweb by ADOS Severity Group

Measure	n	M (SD)	t	Cohen's d
		Prekindergarten		
LNF				
Moderate	12	113.46 (16.57)	.21	.07
Severe	52	112.38 (16.25)		
		Kindergarten		
LNF				
Moderate	9	110.00 (19.68)	−.21	−.08
Severe	40	111.30 (15.85)		
LSF				
Moderate	4	102.00 (14.00)	1.61	.85
Severe	36	89.11 (15.33)		
		Grade 1		
PSF				
Moderate	4	97.57 (15.90)	2.53*	1.33
Severe	36	79.00 (13.76)		
NWF				
Moderate	4	117.55 (33.92)	1.43	.75
Severe	36	98.68 (24.15)		

Note. ADOS = Autism Diagnostic Observation Schedule; LNF = letter-naming fluency; LSF = letter sound fluency; PSF = phoneme segmentation fluency; NWF = nonsense word fluency.
* $p < .05$.

$d = -.08$), meaning there were no differences in LNF performance among children with mild−moderate versus severe autistic symptomology. Likewise, the t tests indicated that there were no significant differences between the mild−moderate and severe groups on LSF, $t(38) = 1.61$, $p = .12$ (despite a large effect, $d = .85$), or NWF, $t(38) = 1.43$, $p = .16$ (medium effect, $d = .75$).

However, there were significant differences on PSF, $t(38) = 2.53$, $p < .05$ (large effect, $d = 1.33$), such that the mild−moderate group had higher performance ($M = 97.57$, $SD = 15.90$) than did the severe group ($M = 79.00$, $SD = 13.76$). There was only one child in the mild−moderate group who had completed R-CBM, so no analyses were conducted for this measure.

Discussion

Examining Similarities and Differences in Reading Development

Similarities and differences between this sample of high-functioning students with ASD and the typically developing population, as well as between mild−moderate and more severe ASD symptom groups, were observed in reading skill areas. Also of note was the large variability in skills within the ASD sample, which impacted multiple analyses.

Superior skills in ASD. The findings of this study extend previous research suggesting that letter-naming ability of children with ASD is higher than that of same-age peers on CBM measures (AIMSweb), specifically for this sample of high-functioning students with ASD. Further, students displayed similarly high skills even across different levels of ASD severity. Students with ASD generally perform higher than do their same-age TD peers on "procedural" or rote measures such as letter naming (Lanter, Freeman, & Dove, 2013; Markowitz et al., 2006), possibly due to a preoccupation with printed words (Nation et al., 2006) or preference for rote learning tasks. As this study indicated, differences in letter naming dissolve in first grade, possibly because phonological awareness and phonics skills begin to take precedence, and children in the normative (i.e., typical) population have typically learned their letters by then.

It is interesting that LNF, which assesses both the accuracy and fluency of letter naming, was found to be predictive of reading comprehension outcomes for prekindergarten and kindergarten children to a small degree. In TD children, knowledge of letter names (i.e., letter-naming *accuracy*) is seen as an indicator of reading outcomes (Burgess & Lonigan, 1998; Speece, Mills, Ritchey, & Hillman, 2003), with demonstrated relationships to later reading comprehension (Storch & Whitehurst, 2002). However, the relationship between letter-naming fluency (i.e., both accuracy and *fluency* in naming letters) is more often examined in relation to fluency tasks, rather than reading comprehension tasks (Speece et al., 2003), perhaps because it functions as a sort of rapid naming task well suited for predicting reading fluency (Scarborough, 1998).

The effects of LNF on reading comprehension scores in the current sample may be driven by the children at the higher and lower scoring extremes. It is possible that difficulties in understanding print (i.e., comprehension) as a result of limited automaticity (i.e., fluency), as seen in typically developing students (Perfetti, 1985), has a particularly pronounced effect in students with ASD, making this relationship between fluency and comprehension apparent early on. This may also speak to the differences seen between children with ASD and typically developing children on LNF in prekindergarten and kindergarten but not first grade. Still, it is important to note that in this sample, letter-naming fluency and reading comprehension were assessed within 1 year of each other, meaning that the way reading comprehension was assessed (i.e., WJ-III Passage Comprehension, which begins by asking participants to match pictures to words and phrases) looks different from other reading comprehension tasks used with children once they are more competent readers (e.g., cloze reading tasks, which is the second portion of the WJ-III Passage Comprehension, or comprehension questions). Although children in prekindergarten and kindergarten in this sample attempted the WJ-III Passage Comprehension test, they often reached ceiling prior to completing the cloze reading tasks. Further, LNF was no longer predictive of reading comprehension in prekindergarten or kindergarten once IQ was entered as a control.

Poorer skills in ASD. Conversely, children with ASD performed significantly lower than national norms on a measure of phonological awareness, phoneme segmentation fluency (PSF). In addition to this poorer overall performance, PSF predicted unique variance in reading comprehension, even though studies conducted with TD children have suggested that, of the AIMSweb and DIBELS early literacy measures (i.e., measures other than R-CBM or Oral Reading Fluency [ORF]), NWF is the most predictive of reading comprehension (Burke et al., 2009; Riedel, 2007). Thus, PSF performance may be a uniquely valuable indicator of long-term outcomes for children with ASD, particularly when IQ is not controlled.

This was further emphasized through the results found in the severity analyses; children with severe symptoms, as seen on the ADOS, demonstrated poorer skills than did those with mild or moderate symptoms. Huemer and Mann (2010) also reported findings that might shed light on this issue. Although their measure of phonological awareness (Lindamood Auditory Conceptualization test; Lindamood & Lindamood, 2004) was slightly different from PSF, it functioned as a measure of both decoding and reading comprehension in their sample of children with ASD. Thus, phonological awareness involves many skills, from early literacy skills to oral language skills, and as demonstrated by Huemer and Mann, it is also related to reading comprehension skills.

These findings may suggest a significant deficit in children with ASD. Indeed, the available research has suggested that, consistent with our findings, phoneme segmentation skills are limited in this population (Smith Gabig, 2010). One explanation for this finding concerns the oral nature of phonological awareness and the difficulty associated with the type of task inherent in PSF for students with ASD. This may be why there was a distinction in performance on this task between those with mild−moderate versus severe symptoms, because children with more severe symptoms demonstrate fewer oral language skills. The procedures of phonological awareness assessments are particularly challenging, given the nature of phonological awareness, for children with ASD, who already have trouble following oral directions (Minshew, Goldstein, Taylor, & Siegel, 1994). Students with ASD cannot rely on common skills in rote memorization to do well on PSF tasks, like they might for other reading tasks.

Further, oral language measures have been found to predict reading comprehension in TD children (Nation et al., 2004; Nation & Snowling, 2004) and children with ASD (Nation et al., 2006; Norbury & Nation, 2011). For children with ASD, PSF scores may be capturing their language abilities, which range from very low to more advanced. Indeed, the finding that students with mild−moderate ASD symptoms performed higher on PSF than did those with severe symptoms suggests that oral language deficits may affect performance on this measure, because students with fewer ASD symptoms usually have, by definition, higher oral language skills.

The percentage of students performing at or above benchmark on AIMSweb measures is disconcerting. Although we aimed to see 80% of students at any particular school site performing at this level (Shinn & Shinn, 2002a, 2002b), far fewer students with ASD did so. In fact, on PSF, virtually the opposite pattern was found; 61.5% of students performed at the lowest level. Again, these results point to the wide range and distribution of skills across students along the autism spectrum and suggest that many students with ASD may require extra supports in developing these skills, whereas some meet or exceed the skill levels of their typical peers.

Comparable skills: Phonics and fluency. The results of the analyses for first graders suggested that this sample of students with ASD performed similarly to national norms on NWF. Further, performance on NWF predicted reading comprehension for TD children and children with ASD similarly well, and PSF predicted unique variance in reading comprehension (until the model controlled for IQ). Analyses comparing performance on AIMSweb measures dependent on autism symptom severity (mild−moderate vs. severe) indicated that NWF performance was not significantly different between the groups.

In general, research has suggested that students with ASD without language impairment perform better on nonword reading measures similar to NWF than do those with ASD with language impairment (Norbury & Nation, 2011). Thus, poor performance on nonword reading measures may be due to language deficits. Typically, emergent literacy skills (e.g., phonological awareness and phonics) and oral language skills emerging during preschool precede and affect reading development (Storch & Whitehurst, 2002; Vellutino, Scanlon, & Tanzman, 1991). It follows that lack of successful language development may impede reading development in multiple skill areas. It is possible that these results were not fully replicated in this study because of the sample size, although variances in the two groups were equal; regarding symptoms of autism, there were fewer mild−moderate than severe cases. In any event, the roles of autism severity symptoms and language impairment on reading outcomes in young children with ASD should continue to be explored.

Related to reading fluency, children with ASD in this sample performed no differently from national norms on R-CBM, a general outcome measure, although this sample displayed greater variance. This variance has important implications for school psychologists and teachers, who may not be aware of the range of reading ability, even in a group of young children with ASD who have relatively high cognitive functioning. Whereas the high performance can be explained by a potential preoccupation with printed words (Nation et al., 2006), the extreme underperformance may be related to oral language.

For those in second grade, R-CBM predicted significant variance in reading comprehension, even after controlling for IQ. When CBM measures and their predictive ability are being examined, R-CBM and other oral reading fluency measures are often highly correlated with reading comprehension measures (Fuchs, Fuchs, & Maxwell, 1988; Shinn, Good, Knutson, Tilly, & Collins, 1992), and R-CBM (ORF) is typically the best predictor of reading comprehension (Riedel, 2007). Performance on R-CBM was as predictive of reading comprehension in this sample as it is in TD children.

Thus, these findings converge to suggest that AIMSweb measures may provide relevant information regarding reading skills for high-functioning students with ASD. Beyond this basic finding, measures such as PSF may provide more information in predicting later reading comprehension (because they tend to be a proxy for oral language), above and beyond higher level reading skills such as phonics (i.e., NWF), than what is seen for typically developing students. Due to the great variability in skills as measured by AIMSweb, these measures do provide valuable information about the reading skills of students with high-functioning ASD. Furthermore, AIMSweb measures produced results similar to those of other measures of reading 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. These analyses support their validity for use with this population.

Limitations

Though precautions were taken to ensure the results of this study were robust, there are some limitations to be considered. Recruitment for the study was ongoing, and data for different participants were collected at different times (though all received a fall and a spring assessment). Thus, 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. Additionally, when separated by grade and measure, the sample sizes were small for some measures (especially R-CBM).

Last, this study was conducted before normative updates were provided (e.g., for the WJ-III and the WPPSI–III); however, the norms were appropriate for the time they were administered. These limitations were offset by the benefit of using brief CBMs utilized in public schools throughout the country.

Implications and Future Directions

To expand on the results of the present study, some specific factors should be addressed in future efforts. A longitudinal examination of the development of early decoding skills and reading comprehension through third grade would be prudent, because differences and difficulties in reading comprehension typically develop more in third grade (Rathvon, 2004). Further, it would be beneficial to consider other updated measures of reading comprehension, rather than primarily a cloze reading task, because the measure used in this study relies more heavily on decoding skills than do other reading comprehension measures (Keenan, Betjemann, & Olson, 2008). Use of additional measures of oral language, expressive and receptive, would be beneficial to tease apart differences.

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 important ways. Although some decoding skills can develop incongruently in 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.

Second, these findings suggest that, for the most part, students with various levels of ASD symptom severity perform similarly on short, timed measures of early literacy (AIMSweb, CBM), with the exception of PSF. This finding has promising implications for students with high autism symptom severity and for educators working with these students, because it suggests that early reading skills may not be as impaired as might be anticipated, based on language skills. The findings regarding PSF are particularly important, including (a) the high variability in skills, (b) the difference in scores dependent on autism symptom severity, and (c) the prediction of reading comprehension skills above and beyond NWF. This provides initial support for the idea that PSF is a proxy for oral language skills to some extent.

In light of these findings, PSF may be more important for predicting reading comprehension for high-functioning children with ASD than it is for TD children. In children with ASD whose oral language skills have not been formally measured (e.g., high-functioning children in early grades who have not been formally assessed for special education), PSF can provide some indication of expressive oral language skills and their potential impact on reading comprehension. Poor performance on PSF could be an indicator that a child with ASD needs early reading intervention and potentially intervention in oral language skills.

Third, there is a great deal of variance to be explained, and other factors beyond decoding skills (e.g., home literacy environment) may help predict additional variance in reading outcome for children with ASD in the early school years. Continued research in this area is imperative because decisions about curricular context and classroom placement for young children with ASD are often made based on reading ability and the interference of autism symptoms. With the exception of PSF, a measure highly dependent on the oral language skills of the student, this study found no evidence of differences in early literacy skills based on autism symptom severity in young children with ASD.

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