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ORIGINAL PAPER

Comparing Children with ASD and Their Peers' Growth in Print Knowledge

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Abstract Many children with autism spectrum disorder (ASD) struggle with reading. An increased focus on emergent literacy skills—particularly print knowledge—might improve later reading outcomes. We analyzed longitudinal measures of print knowledge (i.e., alphabet knowledge and print-concept knowledge) for 35 preschoolers with ASD relative to a sample of 35 typically developing peers. Through multilevel growth curve analysis, we found that relative to their peers, children with ASD had comparable alphabet knowledge, lower print-concept knowledge, and acquired both skills at a similar rate. These findings suggest that children with ASD are unlikely to acquire print-concept knowledge commensurate to their peers without an increased emphasis on high-quality instruction that targets this skill.

Keywords Autism · Emergent literacy · Print knowledge

Introduction

Although children with autism spectrum disorder (ASD) represent a heterogeneous group with varied literacy profiles, many have substantial deficits in at least one major area of literacy. Individual children with ASD may struggle with decoding words (Nation et al. 2006; Wei et al. 2015), reading fluency (Kamps et al. 1994), and/or comprehending text (Nation et al. 2010; Ricketts et al. 2013). One commonly reported profile involves a large discrepancy between decoding skills that are similar to typically developing (TD) peers and reading comprehension that is substantially behind grade level (Nation et al. 2010; Ricketts et al. 2013; Wei et al. 2015). However, these same studies report sizable variability, including a number of individual children whose skills do not fit the group profile. For example, some children with ASD struggle with all aspects of literacy, and therefore have decoding and comprehension skills that are uniformly low compared to TD peers (Nation et al. 2010; Wei et al. 2015).

These deficits pose an enormous barrier to the academic success of children with ASD, and are exacerbated over time as older children are expected to take increased responsibility for learning curricular content from written text (Mastropieri et al. 2003). By the time children reach middle and high school, success in core academic content areas requires proficient literacy skills (Heller and Greenleaf 2007). Many children with ASD—even those who do not have intellectual disability—struggle with academic achievement because of difficulty with independently comprehending text (Minshew et al. 1994). Improving academic achievement for these children requires identification of intervention pathways that promote a more positive trajectory of literacy skills.

For TD children, a focus on emergent literacy during the preschool years has been a fruitful avenue for improving later reading outcomes. Researchers have identified a number of emergent literacy skills that are strong predictors of later success with reading for children without disabilities (National Early Literacy Panel [NELP] 2008). In particular, print knowledge during the preschool years may be one of the most powerful predictors of how well a child will read in early elementary school (Hammill 2004). Two important

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components of print knowledge highlighted by the NELP are alphabet knowledge and print-concept knowledge. Alphabet knowledge—a child's ability to identify letters of the alphabet by their name and sound—is a strong predictor of decoding words and reading fluency (Schatschneider et al. 2004). Print-concept knowledge—a child's knowledge about book and print organization—predicts a child's later ability to decode written words and comprehend reading passages (Piasta et al. 2012). Together, these two skills represent two critically important precursors to decoding and understanding written language.

Emergent literacy, and its role in the acquisition of conventional literacy skills, is not as well understood for children with ASD. A handful of studies provide some initial insight into the print knowledge of young children with ASD. Across four published studies (e.g., Davidson and Ellis Weismer 2014; Dynia et al. 2014; Lanter et al. 2012, 2013) and one unpublished doctoral dissertation (Rosenberg 2008), several common findings emerge. First, as a group, children with ASD have a discrepant profile of print knowledge consisting of alphabet knowledge that is comparable or superior to TD peers but print-concept knowledge that lags behind peers. Researchers have pointed out the parallel between this discrepant profile and later discrepancies between decoding and reading comprehension for older children with ASD (e.g., Lanter et al. 2012). Second, subsets of children do not fit the group profile that is characterized by a discrepancy between skills. Clusters of children with ASD have profiles characterized by low performance (Lanter et al. 2012, 2013) or high performance (Davidson and Ellis Weismer 2014) across both skill areas. Third, heterogeneity in print knowledge seems to be related to overall functioning and deficits that are directly related to ASD. Researchers have identified associations between emergent literacy and cognitive skills (Davidson and Ellis Weismer 2014; Rosenberg 2008), language skills (Dynia et al. 2014; Lanter et al. 2012), and social skills (Davidson and Ellis Weismer 2014; Lanter et al. 2013). These cross-sectional studies provide snapshots of emergent literacy development during the preschool years, but it remains unclear how emergent literacy skills develop over time for children with ASD.

TD children make substantial gains on emergent literacy skills during the preschool years. Based on means and standard deviations reported in a large descriptive study, TD children make large gains in alphabet knowledge ($d = 0.78$) and even larger gains in print-concept knowledge ($d = 1.43$) over an 18-month period from preschool to kindergarten or first grade (Lonigan et al. 2000). Results from other studies suggest that children with disabilities may struggle to keep up with this rapid pace of learning. For example, descriptive statistics from a control group in a recent randomized controlled trial indicate that children with language impairment make smaller gains in alphabet knowledge ($d = 0.39$) and moderate gains in print-concept knowledge ($d = 0.49$) from fall to spring during 1 year in preschool (Justice et al. 2015). Given this large difference in the trajectories of TD children and children with language impairment, one might expect differences in the trajectories of children with ASD—who are characterized by substantial impairments in communication—to be even more pronounced. Furthermore, empirical evidence that children with ASD tend to have atypical print knowledge profiles (e.g., Dynia et al. 2014) and often struggle later with conventional reading skills (e.g., Nation et al. 2010) provides more reason to believe that acquisition of print knowledge may not follow a typical trajectory.

Given these indications that children with ASD might have atypical early literacy trajectories, it is somewhat surprising that these trajectories have not been well studied. Currently, there are no published data that describe changes in the emergent literacy profiles of young children with ASD over time. Indeed, researchers have identified the lack of longitudinal studies as a critical limitation of the existing literature (e.g., Lanter et al. 2013). The understanding of literacy development for this population is limited to cross-sectional data that does not allow for analysis of learning trajectories. Measuring and studying these trajectories could lead to improved understanding of early literacy development for children with ASD and facilitate improved literacy intervention programs.

In the present study, we aim to better understand how children with ASD acquire print knowledge across the preschool years through analysis of longitudinal data. In a previously published study (i.e., Dynia et al. 2014), we focused on emergent literacy skills of children with and without ASD when they entered preschool. In this follow-up analysis, we analyze the print knowledge scores of these same children as they progress through preschool and kindergarten. Specifically, we address the following research questions:

1. To what extent are there differences in alphabet knowledge and print-concept knowledge between children with ASD and their TD peers at the end of kindergarten?
2. To what extent are there differences in the trajectories of alphabet knowledge and print-concept knowledge between children with ASD and their TD peers as they progress through preschool and kindergarten?

Method

The current study is an examination of children with ASD and their peers' growth in print knowledge. This study builds upon a previous investigation of children with ASD and their peers' emergent literacy skills (Dynia et al. 2014). These two studies are secondary data analyses of a larger book-reading intervention called Sit Together and Read (STAR-2; see Justice et al. 2015 for a description of the larger study). Exclusionary criteria, based on a teacher-reported screener, for eligibility for children in the larger study included (a) English language learners that spoke little or no English and (b) children with severe cognitive and behavioral delays that would limit their ability to participate in the larger study.

Participants

Participants in the current study were a subset of children from the larger study including children with ASD ($n = 35$) and TD children ($n = 35$). Children with ASD were identified via teacher report. Teachers reported whether children had an educational diagnosis of ASD based on review of the child's individualized education plan (IEP) and all children from the larger study who had an educational diagnosis of ASD were included in the present study. TD children were selected from a pool of 256 children from the larger study who had completed direct measures of emergent literacy skills but did not have a known ASD diagnosis. The final group of TD children were selected using a two-part process. First, children were removed from the pool of participants if they had (a) standardized language scores that were not in the average range (i.e., more than 1 SD above or below the normative mean on the Clinical Evaluation of Language Fundamentals Preschool, Second Edition; Wiig et al. 2004) or (b) an educational diagnosis of a disability (e.g., ASD, Fragile X, cerebral palsy). After this step, there were 73 eligible peers remaining. Second, the final TD group (30 males and 5 females to match the gender ratio of the ASD group) were randomly selected from the remaining pool of children.

There were no statistically significant differences between the two groups with respect to age ($\chi^2 = 68.00$, $df = 65$, $p = .38$), maternal education level ($\chi^2 = 7.10$, $df = 8$, $p = .53$; unreported for 8 children), or total family income ($\chi^2 = 20.51$, $df = 16$, $p = .20$; unreported for 8 children). There was a significant group difference for race ($\chi^2 = 8.95$, $df = 3$, $p = .03$; unreported for 6 children), with descriptive results indicating that children with ASD identified more frequently as Black. The significant difference in race was a result of selecting TD participants. Once participants were removed from the pool of eligible children based on oral language ability and disability status, these participants did not happen to match the ASD group with regard to race. Therefore, we have controlled for race in our analysis (see description of conditional models). Detailed demographic information for both groups is reported in Table 1. Oral language ability was examined for both children with ASD and their peers; as expected, children with ASD had lower oral language skills ($M = 68.3$, $SD = 19.6$, range 45–106) than their peers ($M = 93.9$, $SD = 5.8$, range 86–106).

Table 1 Demographic information for children with ASD and their peers

	Children with ASD		Peer group	
	n	%	*n*	%
Race				
White	21	60	33	94
Black	7	20	1	3
Asian	1	3	0	0
Other	1	3	0	0
Unreported	5	14	1	3
Maternal education				
Some high school	3	9	1	3
High school	13	37	14	40
Associate's degree	3	9	2	6
Bachelor's degree	4	11	9	26
Master's degree	7	20	6	17
Unreported	5	14	3	8
Total family income				
Less than \$25,000	7	20	5	14
\$25,001–\$65,000	7	20	7	20
More than \$65,001	14	40	22	63
Unreported	7	20	1	3

Settings

Children in the current study were enrolled in 48 different classrooms. The classrooms were located in suburban, urban, or rural areas in a single Midwestern state. The majority of classrooms operated on a half-day schedule, with an average of three adults (teachers and aides) in each classroom ($SD = 1$ adult, range 2–6 adults). The average class size was 11 children ($SD = 4$ children).

Procedures

In the larger study (STAR-2), teachers and caregivers were recruited from early childhood special education (ECSE) classrooms and were instructed to implement a whole-group shared book reading intervention in which they read researcher-provided storybooks for 30 weeks following a prescribed schedule. Teachers and caregivers were assigned to one of three conditions: (a) print-focused/print-focused (PF/PF), (b) print-focused/regular reading (PF/RR), and (c) regular reading/regular reading (RR/RR). In the PF/PF condition, teachers and caregivers were instructed to read using a PF style using an explicit scope and sequence. In the PF/RR condition, only children's teachers read with a PF style and in RR/RR condition, caregivers and teachers read with their typical reading style. Although children were not selected based on their assignment to the three treatment groups, both children with ASD and their peers were distributed equally across study conditions: PF/PF ($n = 10$ children with ASD, 12 TD peers), PF/RR ($n = 14$ children with ASD, 12 TD peers), and RR/RR ($n = 11$ children with ASD, 11 TD peers). Because the intervention was designed to influence children's print knowledge skills, condition, coded as either receiving the treatment at home or school or not receiving the treatment, was used as a covariate in each of the analyses.

There was about 7 % attrition from time point 1 (fall of preschool) to time point 2 (spring of preschool) and about 14 % attrition from time point 2 to time point 3 (spring of kindergarten). For the children with ASD, there was about 9 % attrition from fall to spring of preschool and 22 % attrition from spring of preschool to kindergarten. For the TD group, there was about 6 % attrition between each time point.

Measures

Children participated in assessments at three separate time points: (a) in the fall of their preschool year, (b) spring of their preschool year, and (c) spring of their kindergarten year by trained research staff. Field assessors were considered reliable users of the measures after they: (a) completed a self-guided study of materials and PowerPoint presentation, (b) obtained 90 % on a quiz based on the materials, and (c) were observed delivering the assessments by a master field assessor.

Alphabet Knowledge

Children's alphabet knowledge was assessed using the upper and lowercase subtest of the Phonological Awareness Literacy Screening (PALS; Invernizzi et al. 2004). In this assessment, children identified letter names from a white sheet of paper with upper and lowercase letters printed in a random order for a total possible score of 52. Internal consistency ranges from 0.77 to 0.93 and inter-rater reliability was reported with a Pearson product–moment correlation coefficient of 0.99. Validity for the letter identification task showed correlations of 0.61 and 0.71 with similar assessments (Invernizzi et al. 2004).

Print-Concept Knowledge

Children's print-concept knowledge was assessed using the total score (possible score of 18) on the Preschool Word and Print Awareness (PWPA; Justice et al. 2006). Using the commercially available storybook Nine Ducks Nine (Hayes 1990), assessors ask children questions about word and print awareness (e.g., where are the ducks talking?). Most items receive either a score of zero or one. Some items have a possible score of two, and can receive a score of one if the question is answered partially correct. The inter-rater reliability (point-by-point) is 0.94 and the partial credit model (PCM) ranges from 0.7 to 1.3 (Justice et al. 2006). Item response theory showed that the PWPA represents a single trait that can be estimated with a reliability of 0.74 (Justice et al. 2006).

Results

Descriptive statistics for alphabet knowledge and print-concept knowledge at each time point are shown in Table 2 for children with ASD and their peers separately, as well as a significance test of the differences between the two groups. On average, children with ASD knew more letters than their peers during time points 1 and 2, but their peers knew more letters at time point 3. Children with ASD had lower print-concept knowledge for all three time points.

Unconditional Models

To estimate growth in alphabet knowledge and print-concept knowledge during preschool and kindergarten, a series of multilevel growth curve analyses were fit to the data using HLM (Raudenbush and Bryk 2002) with observations (time points) nested within children. Two different

Table 2 Descriptive statistics for outcome variables

	Children with ASD			Peer group			Δ
	n	*M*	*SD*	*N*	*M*	*SD*	*p*
Alphabet knowledge							
Time 1	35	27.29	21.15	35	23.66	19.05	.453
Time 2	32	33.97	19.99	33	32.70	18.55	.791
Time 3	25	41.20	16.77	31	43.23	12.93	.612
Print-concept knowledge							
Time 1	34	3.09	2.56	35	7.74	3.93	<.001
Time 2	32	5.28	4.34	33	11.03	4.00	<.001
Time 3	25	7.48	4.79	31	12.65	2.87	<.001

Time 1 = the fall of the preschool year, Time 2 = the spring of the preschool year, Time 3 = the spring of kindergarten. Alphabet knowledge = raw score on the combined upper and lower case subtests of the Phonological Awareness Literacy Screener (PALS; Invernizzi 2010). Print-concept knowledge = raw score on the Preschool Word and Print Awareness (PWPA; Justice et al. 2006). Significance tests to detect significance of the difference between the two groups conducted with ANOVA models were developed: (a) one with alphabet knowledge as the dependent variable and (b) one with print-concept knowledge as the dependent variable. Model fitting followed a multi-stage approach for each outcome. First unconditional models (i.e., models with only time point as a predictor) were fit to the data to determine what proportion of the variability in children's alphabet knowledge or print-concept knowledge was attributable to children (level 2) as opposed to the time when the child was tested (level 1). Time was coded to represent months (O'Connell et al. 2013), and was centered at the end of kindergarten for both models. As such, the variance components for the intercept describe variability between children at the third data collection point, the end of kindergarten, and coefficients for time can be interpreted in months.

Results of the unconditional model for alphabet knowledge are presented in Table 3. The estimates in the unconditional model result suggested that the average child score for alphabet knowledge in kindergarten was 43.46 (Table 3, Intercept), with a rate of change of 0.89 new letters learned per month (about 11 letters per year). However, this was only representative of an average. The results of the variance components (bottom of Table 3) supported a model with a random intercept and a random slope for time as the best fit for the data, evidenced by the significant random effects (taus, τ). This means that each child was allowed to have his or her own estimated growth rate. Table 3 also includes the results from the unconditional models for print-concept knowledge. Results of this model supported the random intercept model (τ Intercept $= 14.47$, $p < .001$), but the rate of change did not significantly vary between children (τ Slope $= 0$, $p =$ too small to calculate). This suggested that the average rate of growth in print knowledge was sufficient to explain each child's growth rate, which was estimated at 0.23 points of growth per month, which is significantly different from zero ($p < .001$) and corresponds to 2.76 points gained per year.

Conditional Models

Once an adequate model of growth was determined, a second set of analyses examined the predictors of growth (conditional models). The conditional models were fit with the predictor of interest (i.e., ASD status), a covariate to control for rival hypotheses (i.e., condition), and a dichotomous indicator representing the race of the child (coded as White or not White). We dichotomized race because nearly all children for whom parents reported race were either White or Black (see Table 1). Each predictor was allowed to vary randomly across children, and variance components were examined to determine if their inclusion significantly improved model fit, but none were found to be significant. Thus, the alphabet knowledge model included the same two random effects that were included in the unconditional model phase (intercept and growth), while the print-concept knowledge only included random effects on the intercept (the slope was fixed to be equal across all children).

Results of the conditional models are reported in Table 4. For both outcomes, the covariate of study condition was not found to be a significant predictor, in other words, there were not significant differences in those who received the treatment and those who did not. Given that the treatment condition from the larger study was not a significant predictor for the growth of this particular subset of children, we focused on growth across conditions while controlling for this variable in the model. The focus of this paper is not on the efficacy of the intervention, but on differences in the emergent literacy development between children with and without ASD. Race of the child was a significant predictor, with children who were White scoring significantly higher than those who were not White (estimate $= 24.54$ for alphabet knowledge and 3.51 for print knowledge). For alphabet knowledge, the results indicated that TD (non-White children in the control group) knew about 19 letters in kindergarten. Children with ASD knew

Table 3 Unconditional models estimating growth centered at the end of kindergarten

	Alphabet knowledge				Print-concept knowledge			
	Est	*SE*	*t*	*p*	*Est*	*SE*	*t*	*p*
Estimates								
Intercept	43.46	1.98	21.89	<.001	10.42	0.55	18.78	<.001
Time in months	0.89	0.11	8.23	<.001	0.23	0.02	10.68	<.001
Variance components								
τ Intercept	174.96	40.02	4.37	<.001	14.47	2.81	5.14	<.001
τ Slope	0.34	0.12	2.74	.003	0	–	–	–
σ^2	76.73	12.15	6.31	<.001	5.81	0.75	7.79	<.001

For both alphabet knowledge and print-concept knowledge, the intercept tau and the slope tau were allowed to vary at random

Table 4 Conditional models of growth for alphabet knowledge and print knowledge (centered at time point 3)

	Alphabet knowledge				Print-concept knowledge			
	Est	*SE*	*t*	*p*	*Est*	*SE*	*t*	*p*
Estimates								
Intercept	19.06	5.89	3.23	.002	9.53	1.44	6.64	<.001
Condition	0.61	2.02	0.30	.765	0.23	0.48	0.48	.633
White	24.54	5.17	4.75	<.001	3.51	1.24	2.83	.006
Time in months	0.98	0.15	6.42	<.001	0.23	0.03	7.37	<.001
Autism	5.52	3.92	1.41	.165	−4.35	1.01	−4.30	<.001
Time × autism	−0.20	0.23	−0.86	.392	−0.01	0.05	−0.22	.829
Variance components								
τ Intercept	110.22	30.78	3.58	<.01	7.19	1.73	4.17	<.001
τ Slope	0.30	0.12	2.40	.008	–	–	–	–
σ^2	83.10	13.84	6.00	<.001	6.08	0.82	7.42	<.001

For alphabet knowledge, the intercept tau and slope tau were allowed to vary at random, while for print-concept knowledge, the intercept tau was allowed to vary at random but the slope tau was fixed

approximately five more letters than their TD peers, but this difference was not significantly different from zero (Estimate = 5.52, $p = .17$). For the slope, children gained about one letter per month (estimate = 0.98, $p < .001$). Growth was not moderated by autism status (Time × Autism estimate = −0.20, $p = 0.39$) indicating that both groups grew at approximately the same rate.

This result can be seen in Fig. 1, which plots the estimated growth and intercepts for alphabet knowledge for both children with ASD and their peers, coded by whether the child has ASD. The y-axis is the children's estimated score, with the x-axis representing the three observed time points, and each line represents an individual child. Note that because the slopes were allowed to vary randomly across children there are several different slopes represented (the lines are not parallel). The non-effect of autism status is evidenced by the lines representing children with ASD, which are mixed in very regularly with the slopes representing the TD children; there is no pattern of slopes or intercepts more common based on ASD status.

The estimates for print-concept knowledge can be interpreted in a similar way to those for alphabet knowledge, with children in kindergarten with an estimated score of 9.53 points on the print-concept knowledge test, with an average of 0.23 points of gain per month (Table 4; $p < .001$). Children with ASD were found to end the study with significantly lower scores on print-concept knowledge (estimate = −4.35, $p < .001$). However the gain made by these children was statistically the same; the slope of time was not influenced by autism status (Time × Autism estimate = −0.01, $p = .83$). Just as was done with alphabet knowledge, the estimated results were graphed in Fig. 2. Note in this graph, the slopes were not found to randomly vary between children, therefore all of the lines

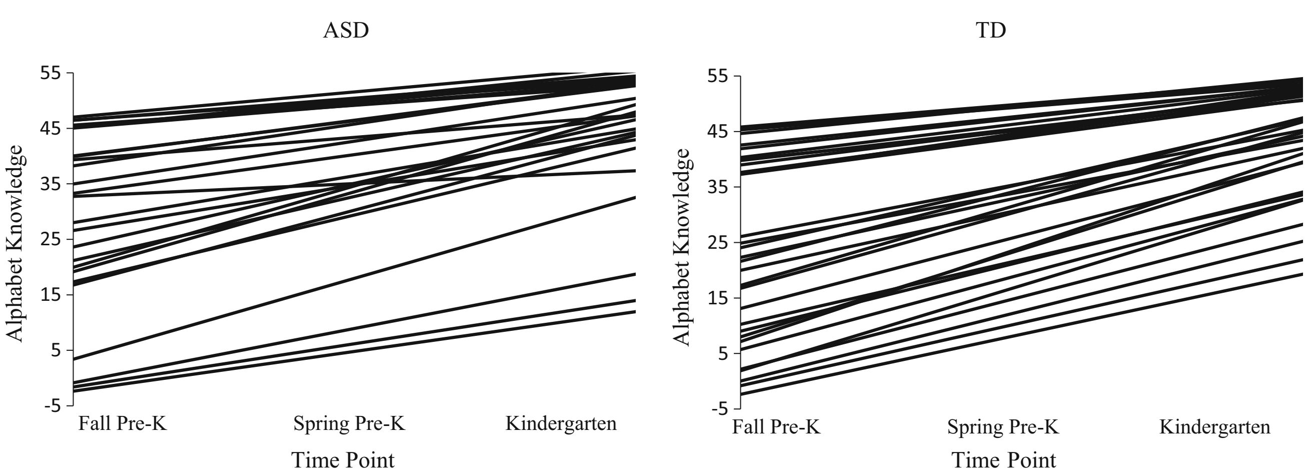

Fig. 1 Growth on alphabet knowledge from preschool through kindergarten for children with autism spectrum disorder (ASD; $n = 33$) and a matched sample of typically developing (TD; $n = 33$) peers

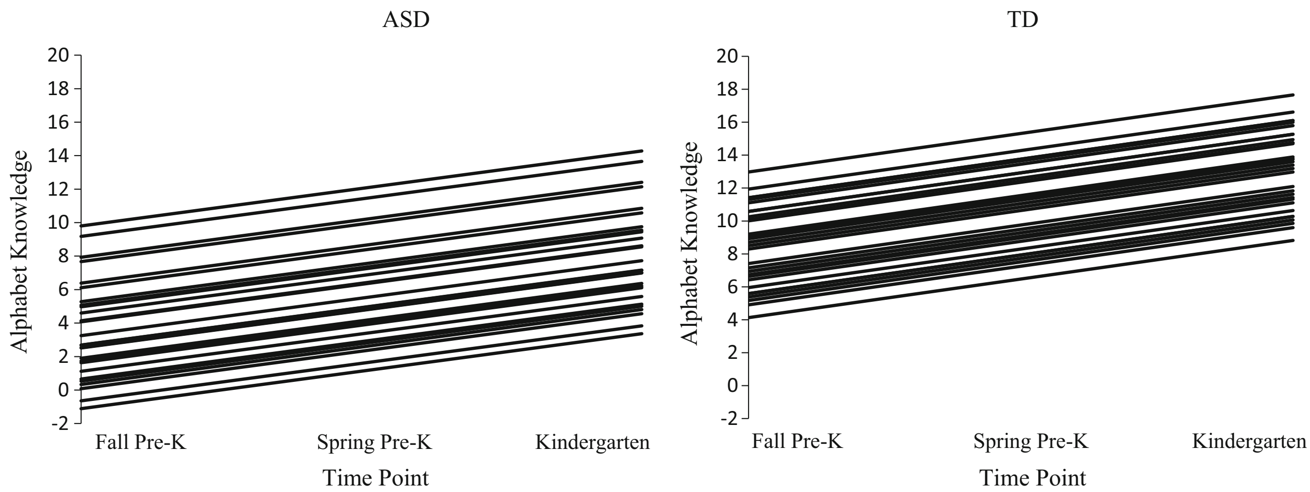

Fig. 2 Growth on print-concept knowledge from preschool through kindergarten for children with autism spectrum disorder (ASD; $n = 27$) and a matched sample of typically developing (TD; $n = 32$) peers

are parallel (they are all equal between children). The significant effect of autism status on the intercept is evidenced by examining the lines representing children with ASD. Though the rate of change is always the same, children with ASD tend to have lower scores than the TD peers (from Table 4, we know the average difference is 4.4 points).

Discussion

Many children with ASD struggle with at least some aspect of literacy, and an increased focus on emergent literacy skills—particularly print knowledge—may have the potential to improve these outcomes. However, the print knowledge profiles of children with ASD are not well understood. Although a handful of published studies provide snapshots of print knowledge for young children with ASD, none examine how these skills develop over time. In the current study, we analyzed trajectories of print knowledge across the preschool years for children with ASD relative to a matched sample of their TD peers. We controlled for rival hypotheses (i.e., experimental condition, race). There were two main findings: (a) compared to their TD peers, children with ASD had similar alphabet knowledge skills and growth trajectories and (b) compared to their TD peers, children with ASD had lower print-concept knowledge and similar growth trajectories. These results extend the research literature regarding emergent literacy trajectories for children with ASD in a number of ways.

First, as a group, young children with ASD seem to learn letters through the preschool years at a similar rate as their TD peers. Cross-sectional studies have already demonstrated similarities in alphabet knowledge at single time points (e.g., Dynia et al. 2014). This study confirms these previous findings, and in addition shows for the first time that growth over time is also similar. This lack of a difference combined with other studies that show children with ASD have significant challenges with conventional literacy, suggests that alphabet knowledge alone probably is not likely the most useful single predictor of later reading problems for children with ASD. This is consistent with descriptions of an uneven profile, where some skills (i.e. alphabet knowledge) are much stronger than other skills. This finding may reflect the ability of children with ASD to memorize and recall discrete symbols; a review of the psychological research shows that for many children with ASD—particularly those categorized as high-functioning—declarative memory abilities are commensurate with same-aged peers (Boucher et al. 2012). On the other hand, this finding challenges the notion that letter identification in ASD is superior to peers (Lanter et al. 2012, 2013). While individual children with ASD from previous studies may have known more letters than TD peers, our analysis of group means did not show significantly differences.

Second, even though children with ASD as a group learned letters at similar rates to their peers, individual trajectories were quite heterogeneous. Based on measures of dispersion (see standard deviations in Table 1) and graphic portrayal of individual trajectories (see Fig. 1), alphabet knowledge was more variable across children with ASD than TD children. This confirms findings from previous cross-sectional research that identified high variability among children with ASD (Dynia et al. 2014; Jones et al. 2009; Lanter et al. 2012, 2013; Nation et al. 2010), and extends these findings by showing variability in growth over time. While this heterogeneity may not be surprising given the diverse abilities of children who are diagnosed with ASD, it is of tremendous practical importance when developing educational programs for individual children. For example, children with ASD were among both the highest and lowest scores on alphabet knowledge for kindergartners in our sample. Clearly, these two particular groups of children would benefit from very different approaches to early literacy instruction. Some researchers have suggested that variability in emergent literacy skills for children with ASD might be related to oral langauge ability (Dynia et al. 2014; Jacobs and Richdale 2013; Lanter et al. 2013). Given that communication skills are one of the primary indicators of severity of ASD, it is possible that early literacy deficits might be related to overall severity of symptomology (see severity ratings in The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition; American Psychiatric Association 2013). However, given that we did not measure ASD severity, we were unable to test this hypothesis in the present study; researchers may investigate this association in future studies.

Third, children with ASD lag behind their peers in print-concept knowledge, and they do not close this gap over time. At the end of kindergarten, children with ASD had lower print-concept knowledge than their peers and their rate of acquiring print-concept knowledge through the preschool years was similar to their peers. Differences at the end of kindergarten mirror findings in some cross-sectional studies on both children with general developmental disabilities (Boudreau and Hedberg 1999; Cabell et al. 2009; Gillam and Johnston 1985) and for children with ASD specifically (Dynia et al. 2014; Koppenhaver and Erickson 2003; Lanter et al. 2012, 2013). For example, two studies by Lanter and colleagues (2012; 2013) examined the literacy skills of 41 and 32 children with ASD respectively, and found that children with ASD had a weakness in print-concept skills. Because children with ASD start out behind their peers and learn at a similar rate to their peers, they are unlikely to meet typical early literacy standards for print-concept knowledge without focused intervention. Print-concept knowledge may be an especially important target for intervention given that it is a powerful predictor of later reading ability (Piasta et al. 2012).

Children with ASD may struggle with print-concept knowledge relative to alphabet knowledge because of differences in the nature of the skills and the way that many teachers may approach each skill. Learning letters of the alphabet is a discrete skill that involves a child responding to the stimulus of a written letter by producing the letter name. Teachers often approach instruction on alphabet letters with explicit instructional methods that involve introduction of letter names, repeated opportunities to for children to practice naming letters, and praise or corrective feedback contingent on the child response (e.g., Levin et al. 2006). A large body of research shows that children with ASD can learn a variety discrete skills given systematic instruction that involves repeated trials with prompting and reinforcement (for a review, see Wong et al. 2015), and a few studies demonstrate that this approach can be successful specifically with teaching letter names to children with ASD (e.g., Benedek-Wood et al. 2015; Travers et al. 2011). In contrast, print-concept knowledge is not a set of stimuli that children memorize, but a collection of concepts about how to navigate written text. While these concepts can be taught using explicit instruction, teachers might not do so naturally without training and coaching (Justice et al. 2009). Instead of explicitly teaching this content, teachers sometimes depend on children acquiring this content through observation and inference—an approach that is less likely to be effective for children with ASD.

It is important to note that about two-thirds of the children with ASD did receive a book-reading intervention at home or school. However, participation in the treatment was not a significant predictor of children's print knowledge at the end of kindergarten. Given that the book-reading intervention has been found to be effective for children with developmental delays (Justice et al. 2015), it may be that children with ASD need a more intense, explicit, or higher dosage of intervention. Future research should also examine treatment intensity of emergent literacy interventions for children with ASD.

Fourth, children with ASD sustained discrepant print knowledge profiles over time. As a group, young children with ASD tend to have higher alphabet knowledge than print-concept knowledge, which seems to parallel discrepancies in older children with ASD between word identification as compared to reading comprehension ability. Our study suggests that the discrepant emergent literacy profile does not seem to improve over time, providing reason to believe that it may be related to discrepancies in conventional literacy skills. The general strength that children with ASD show in alphabet knowledge may be related to their later word reading abilities, given that this association has been found in studies of TD children (Hammill 2004; Schatschneider et al. 2004). Therefore, children with ASD's development of alphabet skills might lead to higher levels of competency in word reading but not advance their reading comprehension ability—which might be more strongly related to print-concept knowledge. This would be consistent with findings for typically developing children that print-concept knowledge in preschool was strongly related to reading comprehension in the first grade (Piasta et al. 2012).

Implications for Practice

The results of this study have important implications for early childhood educators. First, educators should assess emergent literacy skills for all of children to design instruction, because heterogeneity in these skills across both children with and without ASD suggests that different children need different levels of intervention and support. Response to Interventions (RtI) is an evidence-based framework for providing high-quality instruction to all children, with frequent use of progress monitoring to identify children who may require additional intervention to target specific deficits. Second, early educators should be cognizant that although children with ASD may seem to perform very well on emergent literacy skills that are more commonly assessed such as letter identification and letter sounds, they may have deficits in other emergent literacy skills that are important targets for intervention. Simple and practical assessments have been developed to screen preschoolers on print-concept knowledge (e.g., Ohio Department of Education 2004), but these tools are not yet widely used by early childhood educators despite evidence of their potential to improve educational planning (Logan et al. 2014). Without assessment to identify deficits in print-concept knowledge and high-quality intervention to target these deficits, our findings suggest that children with ASD will consistently lag behind their TD peers.

Limitations and Future Research

There are some limitations to the present study. First, the sample of children with ASD might not be representative of all children with ASD. For instance, although there were children with ASD in the current study that had significant delays in the oral language development, children with ASD that were nonverbal were not included in the sample. In future studies, researchers may want to examine the emergent literacy development of children with ASD that also have severe language delay or that are nonverbal. Although our study focused on measures of emergent literacy for children who communicate verbally, there are validated measures specifically designed for children with complex communication challenges (e.g., the Nonverbal Literacy Assessment; Baker et al. 2010). It is also unknown if children with comorbid conditions (e.g., intellectual disability and ASD) would have similar emergent literacy development. Second, the size of our sample limited our statistical power, which might have obscured differences that exist between groups. In future studies, researchers could use larger sample sizes to determine if differences can be detected with more statistical power.

Third, data for 20 % of children was not available at the third time point. Although this attrition rate has been found in other studies of emergent literacy (e.g., Lonigan and Whitehurst 1998; Justice et al. 2011), it is unknown if the children that did not complete study were qualitatively different from the children that did complete the study. Furthermore, the ASD group had deferentially higher attrition. This may have influenced our findings. Fourth, we identified children with ASD based on teacher report of educational diagnosis. In future studies, stronger conclusions could be made if researchers confirmed ASD diagnosis through independent administration of gold-standard diagnostic tools. Fifth, although we controlled for demographic differences (e.g., race), this information was missing for more children in the ASD group than the TD group; it is possible that this could have influenced our findings. Finally, this study focused only on print knowledge. Although print knowledge is a strong predictor of conventional literacy, other emergent literacy skills are also predictive of later reading skills that deserve further study. Moreover, children with ASD's atypical development in print-concept knowledge (and other global literacy skills) may be related to their later difficulties in reading comprehension. However, given that the present study did not measure comprehension, more work needs to be done to: (a) examine how specific emergent literacy skills predict specific conventional literacy skills for children with ASD and (b) to examine how conventional literacy skills change over time for children with ASD.

Conclusion

Children with ASD are at risk for poor reading outcomes that impact all aspects of academic achievement. Increased emphasis on emergent literacy skills during the preschool years might improve these outcomes. This study provides some initial insight into how children with ASD acquire print knowledge over time, and highlights a persistent gap in print-concept knowledge. Through further study of emergent literacy skills for children with ASD, and development of effective interventions that are designed to address deficits, we can empower early childhood educators to deliver instruction that improves the literacy trajectories of young children with ASD.

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