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Phonological awareness emergence in preschool children with autism spectrum disorder

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Abstract

Background and aims: Phonological awareness begins to develop during the preschool years and is a primary factor underlying later reading abilities. Previous research has found mixed results on the phonological awareness skills of children with autism spectrum disorders. Therefore, the purpose of the present study is to add to our understanding of phonological awareness in children with autism spectrum disorder by investigating residualized gains in phonological awareness skills over an academic year.

Methods: A total of 125 preschool (4- to 5-years old) children including 27 children with autism spectrum disorder, 28 children with language impairment, and 70 typically developing children were the focus of the present study. Participants in the current study represent a subset of participants from a larger study titled, Sit Together and Read. Children completed direct assessments in the beginning (fall) and end of school year (spring) on phonological awareness using the Test of Preschool Early Literacy.

Results: A one-way ANOVA compared the phonological awareness skills tasks (syllable/onset-rime, blending/elision, receptive/expressive) in the fall and the spring for each of the three groups (children with autism spectrum disorder, children with language impairment, children who are typically developing). In the fall and the spring, all of the analyses were found to be statistically significant. A Tukey HSD further indicated that children with autism spectrum disorder had significantly lower scores on all of the tasks at both time points compared to the typically developing peers. Children with autism spectrum disorder seem to make gains in phonological awareness tasks similarly to their typically developing peers for most of the phonological awareness tasks. Results from the final regression models indicated that children with autism spectrum disorder made gains similar to those of their typically developing peers for most phonological awareness tasks and that language skills predicted residualized gain for syllable, elision, and receptive tasks, as well as the total score when controlling for condition, IQ, and group status. Social skills were not a significant predictor for any of the tasks.

Conclusions: Three main findings emerged: (a) phonological awareness skills seem to be a deficit for children with autism spectrum disorder, (b) in general, autism status does not predict residualized gain in phonological awareness skills, and (c) oral language is a significant predictor of residualized gain in phonological awareness skills.

Implication: Early childhood educators should focus on providing high-quality instruction on phonological awareness for children with autism spectrum disorder and researchers should focus on investigating the effectiveness of phonological awareness interventions for children with autism spectrum disorder.

Keywords

Autism spectrum disorders, language impairment/disorder, literacy, phonological awareness

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Phonological awareness (PA) is "the ability to detect, manipulate, or analyze, the auditory aspects of spoken language (including the ability to distinguish or segment words, syllables, or phonemes), independent of meaning" (Lonigan & Shanahan, 2009, p. 3). This skill begins to develop during the preschool years (Carroll, Snowling, Stevenson, & Hulme, 2003) and follows a consistent developmental pattern – the ability to manipulate large units of sound emerges prior to the ability to manipulate smaller units of sound (Anthony & Francis, 2005; Carroll et al., 2003). Research has indicated that PA emerges as a part of typical language development (Carroll et al., 2003) and is a primary factor underlying later reading abilities (e.g. Catts, Fey, Zhang, & Tomblin, 2001; Dynia, Brock, Justice, & Kaderavek, 2017; Ehri et al., 2001; Lonigan, Burgess, & Anthony, 2000). For instance, PA has been shown to be one of the best predictors of typically developing (TD) children's word reading skills (Kirby, Parrila, & Pfeiffer, 2003; National Early Literacy Panel, 2008). One study has examined the predictors of decoding for children with autism spectrum disorder (ASD) (Dynia et al., 2017) and found that PA is also a significant predictor of decoding for children with ASD. Moreover, based on the effect size for the interaction between ASD status and PA, findings suggested that PA might have a greater impact on the decoding skills of children with ASD than their TD peers (Dynia et al., 2017).

PA skills and children with ASD

PA skills are related to later reading development (National Early Literacy Panel, 2008). The relationship between PA skill acquisition and later reading development has been widely studied in children with language impairment (LI) with research indicating that although there is large variability in PA skill development, a large number of children with LI demonstrate delayed PA development. For example, in a sample of 218 preschool children with LI, 69% of the children demonstrated delayed PA development (Justice, Logan, Kaderavek, Schmitt, et al., 2015; Justice, Logan, Kaderavek, & Dynia, 2015). However, it should be noted that delayed PA development was not a universal feature of the LI sample; some children in the sample presented with age-appropriate PA skills (Justice, Logan, Kaderavek, Schmitt, et al., 2015; Justice, Logan, Kaderavek, & Dynia, 2015).

Like children with LI, children with ASD are at risk for reading difficulties; yet, little is known about the emergence of PA in children with ASD. To date, only six studies have examined development of PA in preschool-aged children with ASD and these studies yielded mixed results (Dynia, Lawton, Logan, & Justice, 2014; Fleury & Lease, 2018; Hudson et al., 2017; Smith Gabig, 2010; Westerveld et al., 2017; Westerveld, Trembath, Shellshear, & Paynter, 2016). Findings from some studies indicate poorer PA performance (Dynia et al., 2014; Smith Gabig, 2010) whereas other studies report that PA is an area of relative strength for children with ASD (Fleury & Lease, 2018; Westerveld et al., 2017). Like children with LI, there is large variability within the ASD population and the conflicting results reported across the literature may be a consequence of the heterogeneity inherent to the ASD population.

We hypothesize that mixed findings reported across the literature may also reflect differences in task demands, given that it is theorized that PA development follows a continuum (Phillips, Clancy-Menchetti, & Lonigan, 2008). In other words, the level at which the child is expected to manipulate the sound (i.e. syllable versus phoneme level) influences the difficulty of the task. The hypothesized developmental continuum starts with children's ability to manipulate words and syllables (e.g. foot + ball = football and /mon/+/key/=monkey), and then moves to the ability to manipulate onset-rime (e.g. /d/+/og/ = dog), and eventually to phonemes (e.g. /k/+/a/+/t/ = cat). It is also hypothesized that blending tasks (where a child is expected to take individual sounds and blend them together to create a word, such as blending /k/+/a/+/t/ to say "cat") are developmentally easier than elision tasks (where a child is expected to hear a word and then eliminate a specific sound to create a new word, such as saying "feet" without the sound /t/ to create "fee") and that receptive tasks are easier than expressive tasks (Phillips et al., 2008).

The studies investigating PA development in preschool children with ASD have used measures that included expressive and receptive responses to both blending and elision tasks. For instance, Westerveld et al. (2017) investigated the PA abilities of 57 children with ASD, with a mean age of 4 years, 8 months, using the beginning sound awareness subtest of the Phonological Awareness Literacy Screening for Preschoolers (PALS; Invernizzi, Sullivan, Meier, & Swank, 2004). This subtest assesses children's ability to manipulate onset-rime using an expressive elision task; children repeat a word and then produce the initial sound of the word. Because there was not a TD group, researchers compared the performance of the children with ASD to expected developmental ranges for four-year-old TD children. Seventy-five percent of the children with ASD performed greater than or equal to the expected range (not the standard score), which led the authors to conclude that PA was an area

of particular strength in children with ASD (Westerveld et al., 2017).

Dynia et al. (2014) compared the PA skills of 35 preschool children with ASD, with a mean age of 4 years, 5 months, to their age matched TD peers. PA was assessed using a subtest of the Test of Preschool Emergent Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007), which is comprised of expressive and receptive blending and elision tasks at the syllable, onset-rime, and phoneme level. Performance on the blending and elision tasks yielded an overall PA score. The performance of children with ASD on this global measure of PA was significantly poorer than their TD peers. Similarly, Hudson et al. (2017) examined the effects of literacy interventions on the emergent-literacy skills, including PA, of 133 preschool children with ASD. Based on pretest scores of the TOPEL, children with ASD had an average standard score of 77.43, indicating that children with ASD were about one and a half standard deviations below the mean on a global measure of PA. These findings are consistent with those of Smith Gabig (2010) who compared the performance of 14 children with ASD with a mean age of 6 years, 5 months to a group of age matched TD peers using two tests on the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999). The CTOPP assesses PA at the syllable, onset-rime, and phoneme level using expressive elision and blending tasks. The children with ASD performed significantly lower than their age-mates on both blending and elision tasks (Smith Gabig, 2010). Together these findings indicate that although children with ASD have performed within age-expectations on one expressive elision onset-rime task (Westerveld et al., 2017), across multiple research studies assessing different aspects of PA children with ASD perform significantly worse than their TD peers. Furthermore, examination of the performance of the children with ASD indicates that elision was particularly difficult. Therefore, to gain a deeper understanding of PA development in children with ASD, it may be critical to take a task level approach to assessing performance. Finally, while these studies provide important information about PA development during specific periods in time, to date, no research has investigated residualized gains in PA development. Therefore, it remains unknown whether children with ASD have an atypical pattern of development for PA.

Additionally, it is not clear if children with ASD perform better on receptive or expressive PA tasks, as this has not been reported in the previous literature. In general, findings are mixed regarding the receptive-expressive language profiles of children with ASD. Kwok, Brown, Smyth, and Oram Cardy's (2015) meta-analysis of 74 studies investigating this phenomenon in children with ASD revealed no evidence of consistent atypical receptive-expressive profiles of children with ASD across the literature. However, a recent longitudinal study investigating the receptive-expressive profiles of children with ASD from 30 to 66 months of age highlights the importance of examining receptive-expressive profiles early in skill acquisition. In this study, initial atypical receptive-expressive profiles observed in the children at 30 months decreased over time with atypical profiles being less likely during preschool (Davidson & Ellis Weismer, 2014). To date, no researchers have directly examined the receptive/expressive PA profiles of children with ASD. Examining the receptive/expressive PA profiles of children with ASD enabled us to determine whether an expressive PA skill advantage was observed in children with ASD.

Furthermore, investigating emergent literacy skills in children with ASD many help us better understand the variable reading profiles observed in later development. McIntyre et al. (2017) investigation revealed four reading profiles in children with high functioning ASD between 8 and 16 years of age. The children classified as poor comprehenders presented with strong PA, decoding and word reading abilities and poor reading comprehension. The authors speculate that this subgroup of children may have presented as hyperlexic during their early reading development. A second and third group of children, classified as readers with global disturbance and readers with severe global disturbance, presented with poor performance on all reading and language variables. The fourth group of children were classified as average readers, and performed within age-expectations on all language and reading variables (McIntyre et al., 2017). Davidson and Ellis Weismer's classification of reading profiles of preschoolers with ASD, which assessed alphabet knowledge but no other aspects of PA development, revealed profiles that appear similar to those observed in school-age children with ASD (e.g. McIntyre et al., 2017). The poor comprehender group demonstrated a strength in alphabet knowledge and poorer comprehension of word meaning. A second group presented with overall poor performance across measures and a third group presented with intact performance across measures (Davidson & Ellis Weismer, 2014). These studies indicate that, like children with LI, children with ASD demonstrate variable reading performance, which emerges early in development. Furthermore, children with ASD with poor PA skill development may be at risk for overall global reading delays, whereas children with intact PA skill development may become classified as average readers or poor comprehenders.

Children with ASD's PA skills and ASD symptomatology

Current research findings suggest that "the risk for reading comprehension disability may be related to ASD symptomatology and be a component of the social-communicative and cognitive phenotype of school-aged children with ASD" (McIntyre et al., 2017, p. 1089). Similar to oral language, reading is a form of communication that relies on the ability to understand an author's intentions as well as the development of "semantic and episodic knowledge typically developed through socially-mediated learning" (McIntyre et al., 2017, p. 1089). Like the development of semantic and episodic knowledge, PA skills may develop through social-mediated learning, making the development of these skills vulnerable for children with social-communicative difficulties. There is also some evidence that children with ASD's performance on emergent-literacy skills is related to their autism symptomology including language and social skills (Davidson & Ellis Weismer, 2014; Dynia et al., 2014). In the previous emergent-literacy studies, children with ASD had significantly poorer language skills than their TD peers leading researchers to explore the association between language skills and PA performance. Dynia et al.'s (2014) regression analysis revealed that language ability was a significant predictor of PA. This relationship between language abilities and performance is consistent with research indicating a positive relationship between receptive vocabulary and elision task performance in children with ASD (Smith Gabig, 2010). The fact that many children with ASD demonstrate delays in their early receptive and expressive language development (Ellis Weismer, Lord, & Esler, 2010; Paul, Chawarska, Cicchetti, & Volkmar, 2008) suggests that PA development may be vulnerable in this population.

The relationship between language performance and emergent-literacy skills is not unique to children with ASD. Children with LI frequently have poorer emergent-literacy skills relative to their TD peers (Justice, Logan, Kaderavek, Schmitt, et al., 2015). LI is defined as impaired understanding and use of spoken language without concomitant physical, neurological, or cognitive deficits (Bishop, 1997; Leonard & Deevy, 2006). Like children with ASD, children with LI are more likely to have impairments in their literary-skill development. The individual emergent-literacy profiles among children with LI have variable strengths and weaknesses among code-related and meaning-related skills (Cabell et al., 2010). However, code-related skills have mostly been targeted in studies in terms of their effect on LI children's emergent literacy (Boudreau & Hedberg, 1999; Justice, Bowles, & Skibbe, 2006; Justice, Kaderavek, Bowles, & Grimm, 2005; Whitehurst & Lonigan, 1998). Additionally, these code-related skills appear to contribute to the significant underachievement in reading seen among children with LI during their school age years. Approximately, 50% of kindergarten children with LI will show reading disabilities by the second grade (Catts, Fey, Tomblin, & Zhang, 2002; Catts, Hogan, & Fey, 2003). Although children with ASD and LI both demonstrate impaired emergent literacy skill development, it is unclear whether the same variables underlie these impairments. Language impairment may underlie the delayed PA skill development observed in children with LI and ASD. If this is true, then only children with ASD and concomitant LIs should demonstrate impaired PA skill development. However, it is also possible that the social skill impairments that are a defining feature of ASD will be negatively related to PA skill development.

There is evidence that social skills are related to preschool-aged children's emergent-literacy development (Doctoroff, Greer, & Arnold, 2006; Kaiser, Hancock, Cai, Michael, & Hester, 2000; Lonigan et al., 1999). Furthermore, there is also some preliminary evidence that the social skills of children with ASD are related to their emergent-literacy skills (Davidson & Ellis Weismer, 2014). For example, Davidson and Ellis Weismer (2014) found an inverse association between social skills and alphabet knowledge for children with ASD.

The purpose of the present study is to add to our understanding of PA in children with ASD by investigating residualized gains in PA skills over the preschool academic year. We add to previous work by comparing the development of the children with ASD to both TD children and to children with LI. Both children with ASD and children with LI are more vulnerable to delayed PA development. However, it is possible that differences in symptomatology across children with ASD and children with LI may differentially influence PA development across these populations. More specifically, the social skill impairment of children with ASD in conjunction with language delays may result in a different pattern of PA development for children with ASD relative to their TD and LI peers. This comparison will provide insight into whether children with ASD who demonstrate delayed language development follow the same pattern of PA emergence as children with LI, or whether the emergence of PA skills in children with ASD follows a different developmental pattern.

Therefore, our specific research questions were as follows: (a) do children with ASD demonstrate a different pattern of PA skill emergence (syllable/onset-rime, blending/elision, receptive/expressive) compared to children with LI and their TD peers? (b) are children with ASD's residualized gain (syllable/onset-rime, blending/elision, receptive/expressive) in PA skills

comparable to children with LI and their TD peers? and (c) do aspects of ASD symptomology (language and social skills) predict residualized gain in PA skills (blending/elision, receptive/expressive) for children with ASD while controlling for IQ and group status (ASD, LI)?

Method

Participants in the current study represent a subset of participants from a larger study titled, Sit Together and Read (STAR 2; Justice, Logan, Kaderavek, & Dynia, 2015). Districts and licensed early childhood education programs were recruited for the larger study if preschool children with developmental disabilities were enrolled. Children with language delays were targeted as the focus of the larger study (see Authors for exclusionary criteria). Institutional review board (IRB) approval and informed consent was obtained for all children in the larger study.

Participants

A total of 125 children including 27 children with ASD, 28 children with LI, and 70 TD children are the focus of the present study. The children with ASD represented all children from the larger study with both an educational diagnosis of ASD and who were old enough (>3-years-old) to obtain a standard score on the Kaufmann Brief Intelligence Test (KBIT; Kaufman, 1990). Standard scores for the KBIT are only available for children aged four-years-old and above; therefore, children younger than four were excluded from the present study. Children in the LI sample represented children from the larger study that met three criteria: (a) had a nonverbal IQ score at the beginning of preschool of 80 or above, (b) had standardized oral language scores at the beginning of preschool of 77 and below on the Clinical Evaluation of Language Fundamentals, Preschool (CELF; Wiig, Secord, & Semel, 2004), and (c) did not have any other known diagnoses (e.g. Fragile X syndrome, Prader–Willi syndrome). Children in the TD sample represented children from the larger study that met these three criteria: (a) had a nonverbal IQ score at the beginning of preschool of 80 or above, (b) had standardized oral language scores at the beginning of preschool of 78 or above, and (c) did not have any known developmental disabilities.

There were no statistically significant differences between the three groups for race/ethnicity ($\chi2 = 17.93$, $df = 12$, $p = .12$), child age ($\chi2 = 240.73$, $df = 232$, $p = .33$), gender ($\chi2 = 4.53$, $df = 2$, $p = .10$), total family income ($\chi2 = 42.20$, $df = 32$, $p = .11$), or mother's education level ($\chi2 = 28.16$, $df = 20$, $p = .11$). There was a significant difference for the groups on Nonverbal IQ ($F = 35.69$, $df = 2$, $p = .01$). Children with ASD and LI were an average of about 54 months ($SD = 3.68$ months, Range = 48.47–60.83 months; $SD = 4.83$ months, Range = 45.70–62.70 months, respectively), whereas TD children were an average of 55.62 months ($SD = 5.05$ months, Range = 46.07–67.33 months). See Tables 1 and 2 for full descriptives for all three groups.

Setting

Children in the current study were enrolled in 66 different classrooms in urban, suburban, and rural areas in a Midwestern state in the United States. The majority of classrooms were half-day programs and the average class size was about 12 children (SD = about four children); with an average of about nine children with developmental disabilities (including children with ASD and LI; SD = about four children) and seven TD children (SD = about four children). Given the variability of the settings, it is possible that setting type influenced children's PA skills; however, examining this possible association was not within the scope of the current study.

Procedures

Teachers implemented whole-group shared book readings in their classrooms per the procedures for the larger study (STAR-2), while caregivers read at home with their child twice a week. All children 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). Teachers and caregivers read with a print-focused style in the PF/PF condition utilizing researcher provided storybooks and schedule. Teachers read with a print-focused style and caregivers read with their typical reading style in the PF/RR condition and teacher and caregivers read with their typical reading style in the RR/RR condition. Print-focused style includes adult references to letters and words during book reading (see Justice, Logan, Kaderavek, Schmitt, et al., 2015; Justice, Logan, Kaderavek, & Dynia, 2015 for more information on the intervention). Condition assignment was not an aspect of the inclusionary criteria. Because of random assignment for the larger study, all children were distributed equally across study conditions: PF/PF ($n = 46$ children), PF/RR ($n = 39$ children), and RR/RR ($n = 46$ children).

Measures

PA. The PA subtest of the TOPEL (Lonigan et al., 2007) was administered in the fall and the spring of

Table 1. Demographics for the ASD, LI, and TD samples.

	ASD sample ($n = 27$)		LI sample ($n = 28$)		TD sample ($n = 70$)	
	N	%			*n*	%
Gender						
Male	24	89	22	79	48	69
Ethnicity						
Caucasian	17	63	19	68	57	81
African-American	5	18	5	18	4	6
Asian	1	4	0	0	0	0
Other	1	4	3	10	3	4
Unreported	3	11	1	4	6	9
Maternal education						
Some high school	3	11	3	11	6	9
High school	10	37	18	64	33	46
2-Year degree	3	11	1	4	2	3
Bachelor's degree	3	11	0	0	11	15
Master's degree	5	19	4	14	6	9
Doctorate	0	0	0	0	4	6
Other	0	0	0	0	2	3
Unreported	3	11	2	7	6	9
Total family income						
Less than $25,000	4	15	12	43	18	26
$25,001–$65, 000	7	26	7	25	17	24
More than $65,001	12	44	5	18	26	37
Unreported	4	15	4	14	9	13

ASD: autism spectrum disorder; LI: language impairment; TD: typically developing.

Table 2. Descriptives for the variables of interest.

	ASD sample ($n = 27$)			LI sample ($n = 28$)			TD sample ($n = 70$)		
Fall measures	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Nonverbal IQ	72.07	21.48	53–120	92.93	9.85	81–121	96.96	9.57	81–124
Oral language	67.11	20.27	45–106	63.79	18.21	10–77	89.81	8.34	79–116
Social skills	79.04[a]	14.34	56–112	93.64	17.91	50–130	99.04	13.69	46–130

ASD: autism spectrum disorder; LI: language impairment; TD: typically developing.
[a]$n = 26$.

the academic year. The PA subtest includes 27 items and is a direct assessment of children's blending and elision abilities. For the blending items, children either receptively identify or combine separate sounds (syllable or onset-rime) to form a word. For the elision items, children receptively or expressively identified the word that is remaining after removing the beginning or ending sounds (syllable or onset-rime). Per the manual, the TOPEL PA subtest had adequate reliability (Cronbach's Alpha = .86) and validity (correlations of .65 and .59 with the CTOPP blending and elision subtests). In the current study, descriptives of the syllable total score (12 items), onset-rime total score (13 items), blending total score (15 items), elision total score (12 items), receptive total score (12 items), expressive total (15 items), and the overall total score (all 27 items) are provided for each group for both fall and spring. Although there are items that assess blending at the phoneme level, a total score for the phoneme items are not presented because there were only two items available. Items are overlapping, for example, one item could be

a blending task at the syllable level that is assessed, receptively.

For the final models, the syllable/onset-rime, blending/elision, receptive/expressive, and the overall total score were used. There was adequate reliability for each of the sub scores used in the current study; syllable (Cronbach's Alpha = .82 in the fall and .80 in the spring), onset-rime (Cronbach's Alpha = .76 in the fall and .80 in the spring), blending (Cronbach's Alpha = .87 in the fall and spring), elision (Cronbach's Alpha = .83 in the fall and .85 in the spring), receptive (Cronbach's Alpha = .85 in the fall and .79 in the spring), expressive (Cronbach's Alpha = .84 in the fall and .89 in the spring), and overall total score (Cronbach's Alpha = .89 in the fall and spring).

Language skills. Oral language was assessed in the fall using the Core Language Index of the CELF (Wiig et al., 2004). The Core Language Index is comprised of three subtests: sentence structure, word structure, and expressive vocabulary. In the sentence structure subtest, children receptively identified pictures that match spoken sentences. In the word structure subtest, children selected the word that is grammatically correct to complete sentences. In the expressive vocabulary subtest, children labeled people, objects, and actions in pictures. For reliability, the subtests had adequate test–retest scores ranging from .77 to .91 and Cronbach's alphas of .77 to .95. For validity, the subtests had moderate to high correlations with other tests of language disorders (Wiig et al., 2004). For the purposes of this study, given the large age ranges of the participants, the standard score for the Core Language Index was used for analyses.

Social skills. The Social Skills Rating System (SSRS; Gresham & Elliott, 1990) is a commonly used teacher-reported measure of children's social skills and was administered in the fall of the year. The SSRS provided teachers' ratings of children's social behaviors in the form of a 30-item rating scale. For each item, teachers indicated the frequency (i.e. how often?) that the child demonstrates the behavior or skill (e.g. the child follows your directions) using a three-point rating scale from zero (never) to two (very often). In the analyses, standard scores were used.

Covariates. Condition (coded as either business as usual or receiving the treatment at school or at home) was included as a covariate. Although the treatment was designed to influence children's print knowledge skills and not PA, it was included to control for any possible effects of the intervention. Given that the groups had significantly different scores for nonverbal IQ, standard scores for nonverbal IQ were included in the final models as a covariate.

Results

The children with ASD had lower nonverbal IQ and social skills than the children with LI and TD children, whereas the children with ASD and LI had lower oral language than the TD children. These results are to be expected given the inclusionary criteria for the groups. See Table 2 for full descriptive and ANOVA information.

Research question 1

To answer the first research question, do children with ASD demonstrate different patterns of PA skill development compared to children with LI and TD peers, we completed further descriptive analysis of mean scores for the PA tasks (syllable/onset-rime, blending/elision, receptive/expressive) including a one-way ANOVA to compare groups. See Table 3 for descriptive results and see Table 4 for ANOVA results. A one-way ANOVA compared the PA skills tasks (syllable/onset-rime, blending/elision, receptive/expressive) in the fall and the spring for each of the three groups (children with ASD, children with LI, children who are TD). In the fall and the spring, all of the analyses were found to be statistically significant (see Table 4). The strength of the relationship, as indexed by $\eta 2$, ranged between .05 and .18. A Tukey HSD further indicated that children with ASD had significantly lower scores on all of the tasks (syllable/onset-rime, blending/elision, receptive/expressive) at both time points compared to the TD peers. Children with ASD also had significantly lower scores than the children with LI on three of the PA tasks in the fall (syllable, blending, total score); however, there were not significant differences in these tasks by the spring. Children with LI scored significantly lower than the children who were TD on a few of the tasks (onset-rime, blending, expressive, total score). The majority of the significant differences were found for the spring time point; therefore, children with LI seem to start the fall with similar scores as their TD peers and then by the spring have fallen behind.

Research question 2

In order to answer the second research question, are children with ASD's residualized gains (syllable/onset-rime, blending/elision, receptive/expressive) in PA skills comparable to children with LI and their TD peers, we analyzed linear regression models. Preliminary analyses included bivariate correlations. Results indicated that the outcome variables were moderately positively

Table 3. Descriptives for the PA skills variables for fall and spring.

	ASD sample ($n = 27$)			LI sample ($n = 28$)			TD sample ($n = 70$)		
Fall measures	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Syllable	3.12[a]	2.80	0–8	5.39	3.01	0–12	6.75[b]	2.90	0–12
Onset-rime	2.00[a]	2.55	0–10	3.29	2.45	0–7	4.33[b]	2.59	0–12
Blending	3.50[a]	3.62	0–11	6.00	3.62	0–12	6.96[b]	3.87	0–15
Elision	1.65[a]	2.24	0–8	2.86	2.38	0–8	4.36[b]	2.83	0–10
Receptive	3.96[a]	3.71	0–9	6.07	3.63	0–12	7.55[b]	3.05	0–12
Expressive	1.19[a]	2.32	0–10	2.79	2.54	0–8	3.77[b]	3.20	0–12
Total	5.15[a]	5.23	0–19	8.86	5.16	0–17	11.32[b]	5.35	0–23
Spring measures	ASD sample ($n = 24$)			LI sample ($n = 27$)			TD sample ($n = 68$)		
Syllable	6.00	3.80	0–12	7.33	2.39	2–12	8.57	2.71	2–12
Onset-rime	4.21	3.60	0–12	4	2.06	1–9	6.00	3.06	0–13
Blending	6.46	4.22	0–14	7.14	3.02	0–14	9.37	3.81	0–15
Elision	3.96	3.74	0–12	4.37	2.59	0–12	5.78	3.20	0–12
Receptive	6.79	3.65	0–12	7.74	1.93	3–12	8.53	2.96	1–12
Expressive	3.63	4.44	0–14	3.78	2.99	0–11	6.62	4.02	0–15
Total	10.42	7.42	0–26	11.52	3.99	5–21	15.15	5.77	2–27

ASD: autism spectrum disorder; LI: language impairment; TD: typically developing.
[a]$n = 26$.
[b]$n = 69$.

Table 4. Summary of ANOVA for PA skills.

				Tukey comparisons		Mean diff (I − J)
	F	*df*	η^2	LI	TD	
Fall measures						
Syllable	14.99**	2, 120	0.20	ASD	−2.28*	−3.64**
				LI		−1.36
Onset-rime	8.20**	2, 120	0.12	ASD	−1.29	−2.33**
				LI		−1.05
Blending	7.96**	2, 120	0.12	ASD	−2.50*	−3.46**
				LI		−0.96
Elision	11.02**	2, 120	0.16	ASD	−1.20	−2.71**
				LI		−1.51*
Receptive	11.20**	2, 120	0.16	ASD	−2.11	−3.59**
				LI		−1.48
Expressive	7.58**	2, 120	0.11	ASD	−1.59	−2.58**
				LI		−0.98
Total	13.09**	2, 120	0.18	ASD	−3.70*	−6.17**
				LI		−2.46
Spring measures						
Syllable	7.42**	2, 116	0.11	ASD	−1.33	−2.57*
				LI		−1.24
Onset-rime	5.93**	2, 116	0.09	ASD	0.21	−1.79*
				LI		−2.00*
Blending	6.97**	2, 116	0.11	ASD	−0.69	−2.91**
				LI		−2.22*

(continued)

Table 4. (continued)

				Tukey comparisons		Mean diff (I − J)
	F	*df*	η^2	LI	TD	
Elision	3.78*	2, 116	0.06	ASD	−0.41	−1.82*
				LI		−1.41
Receptive	3.28*	2, 116	0.05	ASD	−0.95	−1.74*
				LI		−0.79
Expressive	8.12**	2, 116	0.12	ASD	−0.15	−2.99**
				LI		−2.84**
Total	7.65**	2, 116	0.12	ASD	−1.10	−4.73**
				LI		−3.63*

*$p = 0.05$.
**$p = 0.01$.

Table 5. Bivariate correlations for study variables.

Measure	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Nonverbal IQ	0.48**	0.42**	0.42**	0.34**	0.30**	0.40**	0.44**	0.23**	0.40**	0.50**	0.40**	0.36**	0.48**	0.43**	0.41**	0.49**
2. Oral language	–	0.27**	0.31**	0.35**	0.27**	0.35**	0.32**	0.30**	0.36**	0.40**	0.42**	0.42**	0.35**	0.35**	0.42**	0.46**
3. Social skills		–	0.35**	0.29**	0.27**	0.31**	0.32**	0.27**	0.34**	0.37**	0.24**	0.28**	0.27**	0.23**	0.32**	0.33**
4. Fall syllable			–	0.77**	0.82**	0.78**	0.87**	0.76**	0.94**	0.50**	0.44**	0.45**	0.43**	0.41**	0.47**	0.51**
5. Fall onset-rime				–	0.85**	0.72**	0.84**	0.78**	0.93**	0.39**	0.47**	0.39**	0.41**	0.43**	0.39**	0.47**
6. Fall blending					–	0.43**	0.71**	0.86**	0.90**	0.36**	0.41**	0.45**	0.28**	0.33**	0.40**	0.43**
7. Fall elision						–	0.82**	0.52**	0.78**	0.47**	0.45**	0.33**	0.52**	0.45**	0.40**	0.49**
8. Fall receptive							–	0.51**	0.89**	0.46**	0.43**	0.36**	0.45**	0.48**	0.35**	0.47**
9. Fall expressive								–	0.85**	0.37**	0.45**	0.47**	0.32**	0.29**	0.48**	0.47**
10. Fall total score									–	0.48**	0.50**	0.47**	0.44**	0.45**	0.47**	0.54**
11. Spring syllable										–	0.72**	0.78**	0.77**	0.78**	0.79**	0.91**
12. Spring onset-rime											–	0.81**	0.78**	0.77**	0.83**	0.93**
13. Spring blending												–	0.45**	0.60**	0.87**	0.88**
14. Spring elision													–	0.79**	0.65**	0.82**
15. Spring receptive														–	0.47**	0.80**
16. Spring expressive															–	0.90**
17. Spring total score																–

**$p < .01$.

correlated ($r = .24$–$.48$) with all of the covariates and variables of interest (nonverbal IQ, oral language, social skills); the correlations between each of the outcome variables were also moderately to strongly positively correlated ($r = .23$–$.94$). See Table 5 for full bivariate correlation results.

When examining the regression models, results indicated that when controlling for condition and IQ, ASD status predicted residualized gain in elision tasks. That is, children with ASD seemed to gain about two points more during the year compared to their TD peers. ASD status was not a significant predictor for any of the other PA tasks (syllable/onset-rime, blending, receptive/expressive); therefore, children with ASD seem to make gains in PA tasks similarly to their TD peers for most of the PA tasks. See Table 6 for full regression results.

Research question 3

For the final research question, do aspects of ASD symptomology (language and social skills) predict residualized gain in PA skills (blending/elision, receptive/expressive) for children with ASD while controlling for IQ and group status (ASD, LI), we examined seven linear regression models. Results indicated that language skills predicted residualized gain for syllable, elision, and receptive tasks, as well as the total score when controlling for condition, IQ, and group status. Social skills were not a significant predictor for any of the

Table 6. Predictors of residualized gain in PA tasks and PA total score.

	Syllable			Onset-rime			Blending			Elision			Receptive			Expressive			Total score		
	B	*SE*	ΔR^2	*B*	*SE*	ΔR^2	*B*	*SE*	ΔR^2	*B*	*SE*	ΔR^2	*B*	*SE*	ΔR^2	*B*	*SE*	ΔR^2	*B*	*SE*	ΔR^2
Constant	−1.63	1.77	–	−2.97	1.85	–	0.45	2.44	–	−5.69**	1.83	–	−0.08	1.83	–	−5.70*	2.37	–	−5.53	3.43	–
Pretest	0.35**	0.08	0.11	0.44**	0.10	0.13	0.36**	0.08	0.12	0.48**	0.09	0.14	0.32**	0.08	0.11	0.56**	0.10	0.16	0.44**	0.09	0.14
Condition	0.28	0.47	0.01	0.19	0.49	0.00	0.58	0.64	0.00	0.05	0.49	0.00	0.06	0.48	0.00	0.56	0.62	0.00	0.60	0.91	0.00
IQ	0.08**	0.02	0.11	0.07**	0.02	0.08	0.06*	0.03	0.04	0.10**	0.02	0.13	0.06**	0.02	0.07	0.10**	0.02	0.10	0.16**	0.04	0.10
ASD	0.87	0.78	0.00	1.13	0.80	0.01	−0.03	1.06	0.00	2.15**	0.80	0.04	1.08	0.80	0.01	1.20	1.03	0.00	2.26	1.51	0.01
LI	−0.40	0.57	0.01	−1.28*	0.60	0.03	−1.58*	0.78	0.02	−0.32	0.60	0.00	−0.08	0.59	0.00	−1.82*	0.76	0.03	−1.88	1.11	0.01
R^2	0.38			0.35			0.29			0.41			0.30			0.39			0.42		

ASD: autism spectrum disorder; LI: language impairment.
*$p < .05$.
**$p < .01$.

tasks. Therefore, language skills seemed related to residualized gain for some PA tasks, but not all of them. See Table 7 for full regression results.

Discussion

The purpose of this research study was to examine the residualized gains in PA skills of children with ASD and LI over a preschool academic year to determine whether these skills follow the same developmental pattern across populations and in comparison to children who are TD. There are mixed findings in the literature regarding PA skill development in children with ASD. Furthermore, although children with ASD and children with LI are at risk for delayed PA skill development, it is unknown whether PA development is differentially influenced across these populations because of symptomology. Therefore, there were three main findings: (a) PA skills seem to be a deficit for children with ASD, (b) in general, autism status does not predict residualized gain in PA skills, and (c) oral language is a significant predictor of residualized gain in PA skills. These findings are discussed in further detail below.

PA skills and children with ASD

Across all of the PA tasks (syllable/onset-rime, blending/elision, receptive/expressive), children with ASD performed significantly worse than children with TD in the fall and the spring. It is important to note that these findings need to be interpreted with caution, given the heterogeneity of children with ASD. These findings are consistent with previous research indicating delayed PA skill development in children with ASD (Dynia et al., 2014; Hudson et al., 2017; Smith Gabig, 2010). However, they differ from those of Westerveld et al. (2017). We hypothesized that these contrasting findings may reflect differences in experimental design. Westerveld et al. used a non-standardized measure of PA performance that tapped one specific ability (i.e. the ability to repeat a word and then produce the initial sound of the word). In contrast, the present study examined the performance of children with ASD on standardized measures of PA skills in comparison to children with TD and children with LI. Furthermore, this is the first study to explore whether children with ASD demonstrate atypical receptive/expressive PA profiles. Unlike studies using other language measures (e.g. Kwok et al., 2015), there was no evidence of an atypical receptive/expressive PA skill profile in the ASD sample in this study. Thus, these findings add to a growing body of evidence that children with ASD have slower PA acquisition, as demonstrated by poorer performance on global PA measures, compared to their TD peers (Dynia et al., 2014; Hudson et al., 2017;

Table 7. Predictors of residualized gain in PA tasks.

	Syllable			Onset-rime			Blending			Elision			Receptive			Expressive			Total score		
	B	SE	ΔR^2	B	SE	ΔR^2	B	SE	ΔR^2	B	SE	ΔR^2	B	SE	ΔR^2	B	SE	ΔR^2	B	SE	ΔR^2
Constant	−5.41*	2.29	–	−5.28*	2.46	–	−9.59**	3.11	–	−2.51	2.40	–	−4.18	3.18	–	−7.91**	2.45	–	−12.13**	4.49	–
Pretest	0.33**	0.08	0.09	0.41**	0.10	0.10	0.51**	0.11	0.18	0.31**	0.08	0.05	0.32**	0.08	0.09	0.46**	0.10	0.14	0.41**	0.09	0.12
Condition	0.32	0.46	0.00	0.24	0.49	0.00	0.66	0.62	0.09	0.05	0.48	−0.08	0.67	0.64	−0.01	0.06	0.49	0.02	0.70	0.90	0.00
IQ	0.06**	0.02	0.05	0.06**	0.02	0.04	0.08**	0.03	0.09	0.05*	0.02	0.01	0.04	0.03	0.03	0.09**	0.02	0.07	0.13**	0.04	0.06
ASD	1.62	0.83	0.02	1.69	0.88	0.02	2.04	1.11	0.09	1.56	0.86	−0.04	1.03	1.14	0.01	2.58**	0.88	0.03	3.66*	1.61	0.03
LI	0.55	0.71	0.00	−0.47	0.75	0.00	−0.94	0.96	0.08	0.85	0.74	−0.08	−0.13	0.98	0.00	0.24	0.76	0.02	0.04	1.38	0.00
Language	0.03*	0.02	0.02	0.03	0.02	0.00	0.03	0.02	0.11	0.04*	0.02	−0.08	0.06*	0.02	0.02	0.02	0.02	0.02	0.07*	0.03	0.02
Social Skills	0.02	0.02	0.01	0.01	0.02	0.00	0.03	0.02	0.09	0.01	0.02	−0.08	0.02	0.02	0.00	0.01	0.02	0.02	0.04	0.03	0.01
R^2	0.41			0.36			0.41			0.34			0.33			0.42			0.45		

ASD: autism spectrum disorder; LI: language impairment.
*$p < .05$.
**$p < .01$.

Smith Gabig, 2010). Although there is mounting evidence that children with ASD demonstrate slower PA development, the underlying cause of this delay remains unknown.

One possibility is that the delayed PA skill development in children with ASD may be a reflection of the concomitant LIs and the highly variable nonverbal IQ observed in a large subset of children with ASD. Interestingly, PA skill development in the ASD group was also delayed relative to the LI group. Furthermore, unlike the children with ASD, the majority of the significant differences in PA skills between the TD and LI groups were found during the spring. This indicates that children with LI enter preschool with PA skills that are similar to their TD peers and delayed PA skill development emerges over the course of the preschool year. In contrast, children with ASD appear to enter preschool with poorer PA skills relative to their TD peers and continue to remain delayed in their development as the school year progresses. Another explanation for the delayed PA skill development in children with ASD may be the phonology skills of children with ASD. Phonology skills have previously been considered a strength for children with ASD (Rapin & Dunn, 2003); however, more recently research has emerged that has shown that school-age children with ASD may have delayed or disordered phonology skills (Cleland, Gibbon, Peppe, O'hare, & Rutherford, 2010; Rapin, Dunn, Allen, Stevens, & Fein, 2009). This is interesting to note, given the association between phonology skills and PA. For example, Rvachew, Ohberg, Grawburg, and Heyding (2003) found that children with delayed phonological skills had lower PA skills in comparison to their peers who were TD.

Residualized gain in PA skills

In the current study, the children with ASD demonstrated similar gains for almost all of the PA skills relative to their TD peers over the course of the academic year. Therefore, because children with ASD started with a delay and made similar gains as their peers, they will not close the gap in PA skills without a specific intervention targeting PA. PA skills may be an especially compelling area for early intervention given the strong association between PA and later decoding skills for children with ASD and their peers (Dynia et al., 2017; National Early Literacy Panel, 2008). For instance, one study on emergent-literacy interventions for children with ASD found that after participation in a PA intervention, children with ASD significantly increased their PA skills (Hudson et al., 2017).

In contrast, ASD status was a significant predictor of residualized gain in elision, such that children with ASD gained two additional points in comparison to

their TD peers. This finding suggests that different mechanisms may underlie elision skill development in children with ASD. Elision tasks require children to take a word and eliminate some of the sounds to create a new word (e.g. say the word cup, now say the word cup without the /k/ sound). During the receptive elision tasks on the TOPEL, children are presented with a panel containing four pictures, one target and three distractors. For the majority of the stimuli, the distractor pictures do not contain any of the sounds or words contained in the target. Thus, the children with ASD may have been using their relative strength in receptive language to make an educated guess (Kwok et al., 2015), rather than demonstrating mastery of elision, during these receptive tasks. Further, in the second set of models controlling for language and social skills, ASD status significantly predicted residualized gain in expressive tasks and the total PA score, such that children with ASD scored almost three and four points higher, respectively, than their TD peers. This may be indicative of a relative strength in these skills that may be capitalized on in future interventions.

PA skills and oral language

It was not surprising that oral language was a significant predictor of some of the PA skills in the current study. Specifically, in the current study, oral language was conceptualized using a composite of vocabulary skills and grammar. Previous studies have found that oral language is related to children with ASD's emergent-literacy skills including PA (Dynia et al., 2014; Jacobs & Richdale, 2013; Lanter, Watson, Erickson, & Freeman, 2012). Additionally, Dynia et al. (2017) found that oral language was a significant predictor of PA for children with ASD. The current study adds to this literature by taking a more nuanced approach to PA. By breaking down PA into the component skills of syllable/onset-rime, blending/elision, and receptive/expressive, and examining associations among the PA skills and aspects of autism symptomology (oral language and social skills), we were able to better tease apart the complex mechanisms that underlie the acquisition of PA skills for children with ASD and LI. For instance, while oral language was a significant predictor of residualized gain for syllable, elision, receptive, and total PA score – oral language was not a significant predictor of onset-rime, blending, and expressive. This suggests that different mechanisms may underlie the acquisition of these PA tasks. Since oral language and nonverbal IQ were moderately correlated, one explanation may be that the covariate of nonverbal IQ was the driving mechanism for these PA tasks given that nonverbal IQ was a significant predictor of onset-rime, blending, and expressive PA tasks. Finally, as the association between oral language and emergent-literacy skills for children with ASD has been well established in the extant literature, we can be confident in these findings; however, it warrants noting that these results should be interpreted cautiously, as the number of statistical analyses in the current study increased the possibility of a Type 1 error.

Surprisingly, social skills were not a significant predictor of any of the PA skills. Although there is some evidence that social skills are related to children's emergent-literacy skills, this evidence is limited and the findings of the present study do not support this hypothesis. This may be because we included a measure of social skills (e.g. cooperation, empathy, and responsibility) and not problem behaviors. Problem behaviors, especially measures of learning related behaviors (e.g. executive function), may influence the ability of children with ASD to access the curriculum and engage in literacy learning. Specifically, previous research has found that observed problem behaviors are related to lower emergent-literacy skills (Arnold, 1997). An area for future research would be to examine if problem behaviors are related to the PA skills of children with ASD.

Implications

Based on the findings of the present study and previous research, it is important for children with ASD to experience high-quality early intervention on PA. The current study has shown that children with ASD lag behind their peers in PA skills and that they do not close this gap over an academic year. Therefore, early childhood educators should provide children with ASD with a more intensive intervention to close this gap. Furthermore, given the differences in PA skills and tasks, early childhood educators should assess children with ASD on each aspect of PA using a variety of tasks to identify children at risk and then provide high-quality instruction on each aspect of PA (syllable/onset-rime, elision/blending, receptive/expressive) for those children with ASD that are lagging behind their peers. Finally, should similar findings be found on larger sample sizes in future research, researchers should focus on investigating the effectiveness of PA interventions for children with ASD. Speech-language pathologists (SLPs) should include literacy goals (including PA) when working with children with ASD. SLPs can also assist the classroom educator in assessment and provide explicit instruction on PA to increase children's skills.

Limitations and future research

This research study is first step toward investigating the pattern of emergence of PA skills in children with ASD

relative to their TD and LI peers. There are three limitations of this study. First, the relatively small sample size may have attenuated any potentially significant associations and also limits the generalizability of these findings. Second, differences related to race and ethnicity are not explored in the current study. This could be a potentially interesting avenue for future research. Third, although the children with ASD had an educational diagnosis of ASD, we were unable to independently confirm this diagnosis. Furthermore, although these findings suggest that children with ASD are using different strategies to support performance on elision tasks; this hypothesis is not directly tested. Thus, these results should be interpreted cautiously. Future research should continue to investigate how the task itself influences performance on different PA tasks to gain greater insight into the strategies that children with ASD are using during these tasks. Additionally, future research should investigate what other factors may be related to children with ASDs' PA skills including diagnostic criteria, home and school context, and language background.

Conclusion

Although there have been mixed findings in the literature on the PA skills of children with ASD, the findings from this research study suggest that children with ASD demonstrated a continued gap in PA during an academic year. Further, children's language skills seem to be related to some aspects of PA but not all. This information will be important for designing effective early interventions for children with ASD and LI.

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