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Phonological awareness in preschool age children with developmental disabilities

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PHONOLOGICAL AWARENESS IN PRESCHOOL AGE CHILDREN WITH DEVELOPMENTAL DISABILITES

by

ANDREA BARTON-HULSEY

Under the Direction of Rose A. Sevcik, PhD

ABSTRACT

Reading skills are critically important for a child's development and continued growth in school. The home and school literacy experiences of children who have developmental disabilities have been found to be qualitatively different from the experiences of their same age peers without disabilities. In addition to access to instruction, a number of intrinsic factors including cognitive ability, receptive language and expressive speech skills have been suggested as factors that may place children with developmental disabilities at a greater risk for limited development of reading skills. Currently, little is understood about how children who have developmental disabilities and may have limitations in productive speech learn to read. This study identifies key intrinsic and extrinsic factors that are related to the development of phonological awareness in 42 children between 4 years and 5 years 9 months of age with developmental disabilities and a range of speech abilities. Aims of this project were to 1- systematically assess children's intrinsic factors of speech ability, receptive and expressive language and vocabulary, cognitive skills and phonological awareness to determine key intrinsic factors related to phonological awareness and 2- describe the extrinsic factors of home literacy experience and preschool literacy instruction provided to children. Children were found to have frequent and positive home literacy experiences. No significant correlations between speech ability and frequency of shared reading experiences were found. Parents reported low levels of preschool literacy instruction. Significant correlations were found between instruction in decoding and word recognition and children's sound-symbol awareness. Correlations were found between the use of technology and media and Augmentative and Alternative Communication (AAC) and children's speech ability. Positive, significant relationships were found between phonological awareness and all direct assessment measures of developmental skill, speech ability and early reading skills but were not found between phonological awareness and home or school literacy experiences. Speech ability did not predict a significant amount of variance in phonological awareness skill beyond what would be expected by cognitive development, receptive language and orthographic knowledge. This study provides important implications for practitioners and researchers alike concerning the factors related to early reading development in children with limited speech ability.

INDEX WORDS: Developmental disability, preschool, reading, phonological awareness, augmentative and alternative communication

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DEDICATION

This dissertation is dedicated to my sister. She is a constant inspiration to my career and the importance of research with children and families with intellectual and developmental disabilities.

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1 INTRODUCTION

The ability to read is fundamental in any child's access to information via print for learning. Reading skills are critically important in a child's development and continued growth in school. From preschool through 3rd grade, children are taught fundamental skills to learn to read. By 3rd grade and beyond, children use reading skills to acquire new academic knowledge. According to the National Assessment of Adult Literacy (NAAL, 2003), fifty-five percent of adults with below basic literacy skills did not graduate from high school. Twenty-one percent of adults with below basic literacy skills had multiple disabilities.

Widely accepted theories of reading development involve foundations of both phonological awareness and language comprehension skills (McArdle & Chhabra, 2004; Perfetti, 1985; Stanovich 1986). Phonological awareness activities are introduced early in preschool and include practicing rhyming words, segmenting words into their component sounds, identifying initial and final sounds in words, and addressing basic letter-sound relationships. These activities are often a key component of preschool instruction and prepare children for learning to read. Children who readily understand rhyme and are able to detect differences in sounds within a spoken word at age 3, have been found to have stronger reading and spelling skills at 6 years of age (Bradley & Bryant, 1991). For many children, the application of phonological structures involved in speaking are readily applied to written orthography in K – 1st grades. Mapping written orthography to phonological knowledge requires mastery of a system that assigns letter shapes to units of speech (Liberman, Shankweiler, & Liberman, 1989). Children are often able to map single letters to their representative speech sounds with ease as a first step in the development of reading. However, reading requires more knowledge than letter-sound correspondences alone. Letter pattern recognition is a key component in reading development that provides a visual context for the development of the integrated components of phonology and morphology. Mastery of the association between the phonological structure of speech, written orthography and semantic content of words is what allows children to become fluent readers. However, the first steps in reading development, i.e., activities of phonological awareness, inherently involve speech production skills to participate. Opportunity for participation in activities of phonological awareness is often limited for children with developmental disabilities who have difficulty producing speech.

It is estimated that in the United States, 15% of children aged 3 – 17 years have one or more developmental disabilities (Boyle et al., 2011). Children with developmental disabilities may have diagnoses of autism, cerebral palsy (CP), intellectual disability (ID), Down Syndrome, and Fragile X among others. In addition, it is estimated that more than 3.5 million Americans or 1.3% of the population evidence a disability that impacts their ability to use speech as a primary means of communication (Beukelman & Mirenda, 2013). Augmentative and alternative communication systems (AAC) are often used by individuals with impairments in speech. The introduction of these systems during early intervention has made positive impacts on children's language and vocabulary development (Romski, Sevcik, Adamson, Cheslock, Smith, Barker, & Bakeman, 2010). The importance of literacy skills for individuals with limited speech ability who require AAC systems cannot be underestimated (Light, McNaughton, Weyer, & Karg, 2008). Individuals who can read and write have access to a means other than speech for communication to convey ideas, thoughts and opinions. Historically, children who use AAC have not been provided the same access to the curriculum for early literacy instruction (Erickson & Koppenhaver, 1995; Light & McNaughton, 1993). In addition to access to instruction, a number of intrinsic factors including cognitive ability, receptive language and expressive speech and language skills have been suggested as factors that may place children with developmental disabilities at a greater risk for limited development of reading skills. Currently, little is understood about how children who are born with developmental disabilities and may have limitations in productive speech learn to read.

The National Reading Panel (NRP) examined the status of research-based knowledge about the effectiveness of various reading approaches for teaching typically developing children to read. It found that instruction in phonics and phonological awareness were highly effective methods along with instruction in vocabulary knowledge (NICHD, 2000). In their report, the NRP suggested that future research include populations of children with disabilities. The Institute for Education Sciences (IES) national center for special education research conducted a review of centers receiving funding for reading research in at risk populations (Connor, Alberto, Compton, & O'Connor, 2014). This IES review found that while the amount of time required to achieve basic literacy skills was substantially longer for children with intellectual and developmental disabilities (IDD) compared to their typically developing peers; relationships between phonological awareness and reading achievement found in students with IDD were similar to those found in their typically developing peers. When examining the literature for research on instruction in phonological awareness specifically for children with developmental disabilities and severe speech impairments, Barker, Saunders and Brady (2012) found only 8 studies, with a total of 26 children that attempted to teach phonological awareness and individual word reading to children with severe speech impairments. In order for adequate reading intervention strategies to be implemented, we must understand the factors at play for children with IDD who have limited speech when learning to read. With recent advances in the use of experimental methods to assess phonological awareness in children with limited speech (Barker, Bridges, & Saunders, 2014; Gillam, Fargo, Foley, & Olszewski, 2011; Preston & Edwards, 2010), there is a need for systematic exploration of the phonological awareness skills of these children at the early stages of reading development. Understanding the impact of speech, language and cognitive ability on the development of phonological awareness is critically needed so we can encourage reading development in children with developmental disabilities as early as preschool. Conners, Rosenquist, Sligh, Atwell and Kiser (2006) found that children with intellectual disabilities of mixed etiologies benefitted from a phonologically based reading instruction. Wise, Sevcik, Romski and Morris (2010) reported that elementary school age participants (n = 80) with mild intellectual disabilities relied on phonological processing abilities to identify words and nonwords. Barker, Sevcik, Morris, and Romski (2013) found that in 294 school-age children with mild intellectual disabilities, children with intellectual disabilities used skills of phonological awareness and language when learning to read just as their typically developing peers. Because of historical limitations in assessment tools for the evaluation of phonological awareness and other reading skills (e.g., letter knowledge, letter-sound knowledge) in children with limited speech, no extant research has examined the factors involved in the development of early literacy skills in preschool age children with developmental disabilities and speech impairment.

This study aims to fill a gap in the literature by determining what factors are most strongly associated with component reading skills of phonological awareness in preschool age children between 4-5 years of age with developmental disabilities. The first aim is to systematically assess and describe children’s intrinsic factors of speech ability, receptive language, cognitive skills and phonological awareness. The second aim of this project is to describe the extrinsic factors of home and school literacy instruction provided to children with developmental disabilities. The third aim is to determine what intrinsic factors are most strongly associated with phonological awareness skills in preschool for children with developmental disabilities. A better understanding of educational practices in reading instruction and the relationship between children's cognitive, language and speech ability to phonological awareness skills will aid practitioners and researchers alike in targeting intervention practices and teacher education for preschool age children with developmental disabilities.

1.1 Development of Phonological Awareness

Phonological awareness (PA) refers to an explicit and conscious awareness of the sound structure of a language and the ability to manipulate segments of phonemes. PA has been found to be an important early skill necessary for successful reading development (McArdle & Chhabra, 2004; Perfetti, 1985; Stanovich 1986; Wagner, Torgesen, & Rashotte, 1994). Ehri (2004) suggests the development of PA begins with an awareness of words that rhyme, then an awareness that words are comprised of component sounds and sound segments (e.g., onsets, rimes) that are blended together to form a word. Finally, children are able to manipulate sound segments of words as evidenced by their ability to perform phoneme deletion tasks (e.g., say smile without the /s/). In order to perform phonological awareness tasks at the level of the individual phoneme however, children must understand that sound blends within a word are further comprised of individual phonemes. The analysis of sounds within a word can be described as happening at two different levels of the linguistic unit, the syllable and the phoneme (Treiman & Zukowski, 1991). For example, the word trip may be divided into individual phonemes of /t/ /r/ /I/ /p/, or it may be divided into an onset syllable /tr/ and rime syllable /Ip/. Treiman and Zukowski (1991) found that children between the ages of 4 and 5 more readily break words first into their component onset and rime syllables rather than into smaller individual phonemic units. Children 7 years of age on average were able to readily identify onset and rime pairs and individual phonemic units. Evidence from Treiman and Zukowski (1991) suggest a developmental progression in phonemic awareness that begins at 4-5 years of age with a child's sensitivity to initial or final syllables within a word that may sound the same (e.g., hammer/hammock), progresses at 5-6 years of age to the ability to distinguish between initial and final syllable sounds that are the same (plank/plea), and culminates at 7 years of age with the ability to distinguish the similarity of individual phonemes (steak/sponge) in a word.

Perfetti (1985) suggests that *linguistic knowledge* may be a more accurate characterization of what children bring to the development of reading than what is described most often as phonological awareness skill. We assess this linguistic knowledge with phonological awareness tasks to understand the relationships between linguistic knowledge and reading development. This relationship between children's knowledge of the sound structure of his/her language and learning to read may be reciprocal such that as children apply phonological knowledge to printed words, they use these printed words to further understand and refine their phonological knowledge. For example, in a longitudinal study by Perfetti, Beck, and Hughes (1981), two kinds of phonemic knowledge were emphasized: Phoneme synthesis (e.g., knowing that /k/ /æ/ /t/ = cat) and Phoneme analysis (e.g., knowing that cat without /k/ = at). Perfetti and colleagues found that children were able to perform phoneme synthesis tasks prior to reading printed words, however the ability to perform phoneme deletion tasks followed progress in word reading. According to Perfetti et al. (1981), children's access to the use of letters to code phonological representations appears to refine children's phonological knowledge. Children may learn to use orthographic patterns as visual representations of speech sounds and begin to then more readily parse the sounds in words.

1.1.1 The Role of Speech.

The knowledge children have about the sound structure of their language is believed to play a critical function in bridging the development of children's speech processes to reading processes (Frost et al., 2009). As Liberman, Shankweiler, and Liberman (1989) discuss, letters do not actually represent the sounds within a word, but instead are the underlying phonology. When three component sounds of a word are blended, the actual sound that is produced is different from its component parts represented by the letters on the page. Children typically first learn individual letter-sound relationships. This relationship deepens as children learn that combinations of letters represent certain sounds that may be different than their component parts first learned by mapping individual letters to sounds (e.g., sh is pronounced /ʃ/ and not /s/ /h/). Results from functional neuroimaging of children between 6 and 10 years of age suggest that as reading develops in children, the brain engages areas to process written language that were originally focused on processing phonological information in speech (Frost et al., 2009).

1.1.2 Children with Speech Sound Disorders.

The relationship between expressive speech ability and phonological awareness has been explored in a number of studies involving preschool age children with speech sound disorders (Anthony et al., 2011; Leitão & Fletcher, 2004; McNamara, van Lankveld, Vervaeke, & Gutknecht, 2010; Preston & Edwards, 2010). Children with speech sound disorders (SSDs) are thought to be at risk for future reading difficulty. In a study to identify factors responsible for the increased risk of reading difficulties in children with SSDs, Anthony et al. (2011) found that when comparing preschool age children with SSDs to same-age peers who had equivalent language ability without SSDs, the children with SSDs performed significantly worse on tasks of phonological awareness, speech perception and speech production. In a study with similar aims, i.e., to examine associations between speech and language impairment and phonological awareness in preschool age children, McNamara et al. (2010) found that children with language impairment were at greater risk for phonological awareness difficulties than children with speech impairment. The PA tasks used by McNamara and colleagues examined only rhyme awareness and beginning sound awareness, while the tasks used by Anthony et al. (2011) assessed PA skills such as elision and blending. According to Ehri (2004), PA skills that rely on only discriminating phonemes in words such as rhyming should not be conclusive of measuring PA with the same rigor as tasks that require children to manipulate sounds in words in tasks such as phoneme blending or elision that lie further along the continuum in the development of phonological awareness. The nature of the PA tasks may have played a significant role in each study’s findings given that elision and blending may require more sophisticated phonological ability than rhyme and beginning sound awareness. In a study by Preston and Edwards (2010) using a range of PA tasks, the relationship between type of speech sound errors preschool children with SSDs made and their phonological awareness skill was further examined. This study used a range of PA tasks beginning by evaluating children’s rhyming skills and ending with assessment of children’s ability to blend individual C-V-C phonemes to create a word. Children’s speech sound errors were categorized into groups according to the characteristics of their errors. The three categories of speech sound errors identified were: sound distortion errors, ‘typical’ sound errors, and ‘atypical’ sound errors. Preston and Edwards (2010) found that children with low receptive vocabulary and more atypical speech sound errors such as unusual, deviant or non-developmentally appropriate errors (e.g., /hu/ for /su/) were associated with lower PA skills. The presence of speech sound errors found in typical development (e.g., /du/ for /su/) and errors characterized by speech sound distortions (e.g., dentalized or lateralized /s/) was not associated with PA skill. The occurrence of distortions and typical speech errors provided little predictive information about PA skill. Findings from Leitão and Fletcher (2004) also suggest that children with atypical speech sound errors are at greater risk for poor phonological awareness. Children with SSDs who have speech errors that are truly deviant in nature may have a more poorly specified phonological representational system that thus impacts phonological awareness skill. Children with SSDs that follow typical developmental patterns but are delayed in their development relative to chronological age, and children who have distortions in specific speech sounds (e.g., children who use lateralized /s/) may be using a more typical phonological representational system that does not impact their phonological awareness skill. This recent research investigating relationships between SSDs and PA skill in preschool age children has provided an important framework to further explore hypotheses related to speech production and PA so that we may better understand differences in children's phonological representational systems that are critical to later reading development. Limited research has been conducted to determine the correlates of speech ability to phonological awareness in children who have significant limitations in speech (e.g., dysarthria, apraxia of speech) such that they are unable to produce functional speech.

1.1.3 **Phonological Awareness in children with limited speech.**

A small number of studies to date have explored the relationship between expressive speech ability and phonological awareness in preschool age children who have limited to no motor speech ability, with a greater number of studies involving individuals who are school-age or adults. (Bishop & Robson, 1989; Card & Dodd, 2006; Foley & Pollatsek, 1999; Gillon, 2005;

Iacono & Cupples, 2004; Sutherland & Gillon, 2007; Vandervelden & Siegel, 1999; Vandervelden & Siegel, 2001). Given that individuals with limited speech ability are a heterogeneous group when it comes to etiology of disability, cognitive ability and language comprehension, the study of the impact of speech ability on phonological awareness is inherently complex. The current literature involving individuals with limited speech yields limited generalizable results, but is comprised of key studies that raise important questions for further exploration. Much of the literature aimed at understanding phonological awareness in individuals with limited speech has been focused on adolescents and adults with typical intellectual ability or mild intellectual disability.

There are very few experimental or published assessment tools to evaluate phonological awareness in individuals unable to speak (Baker, Spooner, Ahlgrim-Delzell, Flowers, & Browder, 2010; Barker, Bridges, & Saunders, 2014; Preston & Edwards, 2010). Historically, the most readily available way to infer phonological abilities has been to use non-word spelling tasks. Non-word spelling ability was explored in 48 individuals between the ages of 10 and 18 with cerebral palsy who were either anarthric or dysarthric (Bishop & Robson, 1989). This study asked if individuals with some access to speech (e.g., dysarthric) were better able to use phonological strategies to spell novel non-words than individuals who had no access to speech (e.g., anarthric). Severity of speech impairment did not affect participants' ability to accurately spell nonwords. Individuals with cerebral palsy who were anarthric were able to spell nonwords as well as individuals who were dysarthric. Foley and Pollatsek (1999) developed experimental measures to assess phonological skills in print with adults with cerebral palsy and severe speech impairment who had at least a 3rd grade reading level. This study asked additional questions about the impact of practice using a speech generating device (SGD) for functional communication on spelling ability. Participants who regularly used SGDs for communication performed better than individuals who did not use SGDs. In these studies of adults with cerebral palsy and roughly average intellectual ability, speech ability did not appear to play a critical role in their development of phonological awareness and ultimate application to print when assessed via nonword spelling tasks. More comprehensive measures of phonological awareness such as word and nonword blending, phoneme counting and phoneme analysis were reported by Iacono and Cupples (2004) in adults with limited speech ability. These assessments were done to better understand the relationship between PA skill and reading skill in adults with limited speech. Positive associations between phonemic awareness and word reading in 34 adults with limited speech ability were found.

Research aimed at understanding the development of phonological awareness in children with no speech ability (e.g., anarthria, dysarthria or apraxia) is limited (Card & Dodd, 2006; Gillon, 2005; Peeters, Verhoeven, van Balkom, & de Moor, 2008; Peeters, Verhoeven, de Moor, & van Balkom, 2009; Vandervelden & Siegel, 1999). Furthermore, studies inclusive of children with mild to moderate intellectual impairment are extremely limited. Studies to date have focused broadly on considerations of PA instruction and the links to reading ability, or the development of adapted PA assessment tools for children with limited speech (Barker, Saunders & Brady, 2012; Johnston, Davenport, Kanarowski, Rhodehouse, & McDonnell, 2009; Machalicek, Sanford, Lang, Rispoli, Molfenter, & Mbeseha, 2010; Truxler & O'Keefe, 2007). In a study to investigate the importance of speech ability in the development of PA, 5 children with cerebral palsy who could speak, and 6 children with cerebral palsy who could not speak between the ages of 6 and 12 were assessed for rhyming ability, phoneme and syllable segmentation, and phoneme identification and manipulation ability (Card & Dodd, 2006). Children who could speak performed better on tasks of phoneme manipulation (elision) and visual rhyme identification tasks, but not on any of the other tasks of PA requiring them to identify the number of syllables or phonemes in a word, identify syllables in the beginning, middle or end of a word, identify spoken rhyming words and read nonwords using an adapted response. This study suggests that the ability to speak may be important for some aspects of PA, but the ability to produce speech is not necessary for the development of all aspects of PA. Therefore, the development of phonological representations may not be entirely dependent on speech ability (Card & Dodd, 2006). Intelligible speech is not suggested to be a prerequisite for phonological awareness, however Card and Dodd (2006) propose that poorer performance on elision tasks (e.g., point to the picture of spin without the /s/) for children unable to speak is due to limited access to an articulatory loop to produce the resulting word. The link between the ability to speak and phonological awareness may play a larger role in this task. Alternately, elision is one of the most advanced phonological skills (Ehri, 2004; Treiman & Zukowski, 1991) and only develops after children begin to read and can readily segment words using a visual representational system similar to that in print (Perfetti, 1985). The participants in the Card and Dodd (2006) study were not fluent readers; therefore their hypothesis concerning the extent to which articulation is engaged to solve elision tasks remains a question. Furthermore, questions about the impact of other cognitive systems such as working memory, executive functioning and auditory processing in children with cerebral palsy with significant motor impairment may be relevant given the task demands when assessing PA via elision tasks (Dahlgren Sandberg, 2001). In a longitudinal study of children between 5 – 6 years of age with cerebral palsy, Peeters, Verhoeven, de Moor and van Balkom (2009) found a strong effect of speech production skill at baseline on phonological awareness 1 year later. Speech production was found to play an important role in the development of PA such that children who had better articulation skills were more aware of the sound structure of their language. Study results showed a linear relationship between the quality of articulation and the phonological short term memory spans of children with cerebral palsy. Vandervelden and Siegel (1999) investigated phonological processing in children and adolescents with cerebral palsy and a range of speech ability. Thirty-two participants with cerebral palsy and no intelligible speech were compared to 32 participants with cerebral palsy and impaired but intelligible speech. A third reading-level matched control group without speech or physical disability also was included. Tasks used in this study were a mix of non-verbal experimental measures to assess phoneme recognition with pictured choices and a range of nonword spelling tasks to infer phonological awareness. There were no significant differences found between participants with cerebral palsy and no speech impairment and participants with cerebral palsy and speech impairment on tasks of phonological awareness. Both groups however did perform significantly lower on average to reading-matched controls without speech or physical disabilities. It is important to note however, that participants with cerebral palsy all scored well above chance on the full range of phonological awareness tasks administered, suggesting that they had developed phoneme awareness in the absence of speech ability. Further research with preschool age children using a range of PA tasks and involves children who have a range of speech ability and etiology other than cerebral palsy is warranted to better understand the implications of limited speech ability on the development of phonological awareness.

1.2 The Role of Speech Perception and other Cognitive Factors

1.2.1 Speech Perception.

In order to execute phonological awareness tasks such as rhyme judgment, onset and rime identification, sound blending and deletion tasks, an individual must have interpreted the speech-sound information accurately. Difficulties in the development of phonological awareness may be in part due to limitations in speech perception (Morais, 1991). When hearing speech, a child must be able to extract discrete phonological representations from phonetic features embedded within the speech signal to provide an output on tasks of phonological awareness and ultimately use this for reading (Boets, Ghesquiere, van Wieringen, & Wouters, 2007). Some studies have found that children with language impairment and reading disability have difficulty with speech perception when speech is embedded within noise (Brady, Shankweiler, & Mann, 1983) while other studies have found that children with reading disabilities have difficulty categorizing speech sounds along certain phonetic dimensions in the same way that typical readers categorize speech sounds (Werker & Tees, 1987). For example, perception of speech sounds has been found to be less sensitive in children with poor phonological awareness skills than children with good phonological awareness skills. The ability to distinguish the difference between two sounds within the same phonetic category such as /ba/ vs /da/ was more difficult for children with reading disability than for children without reading disability (Werker & Tees, 1987). In a study by Boets et al. (2007), the relationship between speech perception and phonological and auditory processing in 5-year old children was examined. Two groups of children were compared, children at high familial risk for reading disability and children at low familial risk for reading disability. When comparing groups of children, Boets and colleagues found that children in the high risk group presented a slight but significant deficit in speech-in-noise perception and no differences in categorical perception. Performance on speech perception tasks require certain levels of attention and automatic processing of stimuli being presented. Often, children who are at risk for reading disability have co-morbid difficulties in information processing. The extent to which other cognitive factors influence speech perception tasks continues to be debated. The current study attempts to understand the speech perception skills of preschool age children with developmental disabilities using an auditory discrimination task.

1.2.2 Auditory Processing.

Speed of auditory processing has been found in some studies to have a relationship to phonological awareness skill. Tallal (1980) claimed that fundamental difficulties in temporal processing underlie disruptions in speech perception, thus explaining the correlations between performance on rapid auditory processing tasks and phonological awareness tasks in children. Marshall, Snowling and Bailey (2001), however, investigated the extent to which rapid auditory processing impacts phonological ability in children with and without reading disability and found no evidence that phonological difficulties are secondary to impairments of rapid auditory processing. Marshall and colleagues used a non-linguistic task to evaluate auditory processing and suggested that phonological ability, or speech perceptual skills may facilitate performance on rapid auditory processing tasks that are linguistic in nature. While the directional nature of the relationship between auditory processing and phonological awareness cannot be confirmed, Barker, Sevcik, Morris and Romski (2013) found that naming speed was a correlate of phonological processing with rapid color and letter naming loading separately on a latent ability of naming speed from tasks of phonological awareness such as segmenting, blending and onset and rime tasks of phonological awareness. This structure of phonological awareness is similar to the structure of phonological awareness found in typically developing children who can read. The contribution of auditory processing in children with developmental disabilities during the development of phonological awareness remains an important area for further research to better define the nature of the relationship between speech perception, auditory perception and performance on phonological awareness tasks. Understanding these relationships in children with developmental disabilities may allow us to define the fundamental components involved in reading development and reading disability.

1.3 The Role of Vocabulary

Vocabulary knowledge is indirectly assessed in tasks measuring phonological awareness (Metsala, 1999; Perfetti, 1985). Vocabulary knowledge has explained the performance on word and nonword tasks of phonological awareness in children younger than 5 years of age (Metsala, 1999). Vocabulary knowledge has been identified as one factor that may explain performance on phonological awareness tasks in children younger than 5 years of age (Metsala, 1999). The vocabulary knowledge that children bring to the task of phonological awareness activities may explain some individual differences in results of phonological awareness assessments. Children may rely on their extant vocabulary knowledge for synthesis and retrieval when blending sounds to make a word and may have greater difficulty when asked to blend nonwords, i.e., to produce a word that has no representational meaning. Metsala (1999) suggested that vocabulary growth in children may help to explain individual differences in emerging phonological awareness skills of blending and nonword repetition. Semantic analysis is apparent at all levels of reading development from the phonological stage forward (Perfetti, 1985).

1.4 Impact of Intellectual and Developmental Disability (IDD) on Phonological Awareness

In children and adults with IDD and developmental disabilities who are able to speak, phonological awareness has been found to have a positive, predictive relationship to reading ability as in children without disabilities (Barker, Bridges, & Saunders, 2014; Bradford et al., 2006; Cupples & Iacono, 2000; Hedrick, Katims, & Carr, 1999; Saunders & Defulio, 2007; Wise et al., 2010). Other studies have found that vocabulary knowledge is a better predictor of reading development than phonological awareness. Steele and colleagues (2013) and Verucci and colleagues (2006) claimed that in individuals with Down syndrome, receptive vocabulary better predicted reading ability than phonological awareness skills did. As discussed earlier, some phonological awareness tasks may be easier than others for an individual and appear to follow a developmental continuum between 3-6 years of age beginning with rhyme and ending with phonemic manipulation. Additionally, as in any task that requires comprehension of complex directions, tasks of phonological awareness may often rely on an individual's language ability to follow the instructions in order to complete the task. It is unclear if the tools used to measure phonological awareness were appropriate for the language ability of the participants. Additionally, it is unclear if vocabulary predicted reading better than PA because the participants with Down Syndrome were using sight word memorization strategies for reading rather than phonological strategies of blending and segmenting to decode words.

Foundations of phonological awareness for individuals with ID are described by Peeters et al. (2008) as skills such as non-verbal reasoning, speech ability, auditory perception, auditory short term memory and vocabulary. Rhyme perception was used as their measure of PA. Peeters and colleagues found that non-verbal reasoning, followed by pseudo word articulation predicted rhyme perception for children with cerebral palsy (CP) and ID. In a control group of children without CP or ID, auditory perception (e.g., differentiating between minimally different word pairs) was a significant predictor of rhyme perception instead. Conclusions from this study suggested that general intelligence and speech ability are important facilitators of early phonological awareness in children with CP. Interestingly, the assessment tool used to assess non-verbal reasoning, i.e. intelligence, was the Raven Colored Progressive Matrices (Raven 1956). This assessment relies on visual pattern recognition as a fundamental skill to complete the matrix tasks. Similarly, rhyme awareness relies on a sensitivity to speech patterns in words to note that two words rhyme. Claiming that general intelligence is a factor in phonological awareness skill for children with ID may over-generalize the results of this study that compared very specific skills and found correlations. Perhaps a third factor is at play, a general pattern recognition skill that underlies participants' performance on both the Raven's and rhyming tasks. Furthermore, van Tilborg, Segers, van Balkom, and Verhoeven (2014) found children's skill in following a rhythm to be a significant factor in predicting phonological awareness along with intellectual ability. When using the Wechsler Intelligence Scale for Children- Third Edition to measure intelligence (IQ), Conners, Atwell, Rosenquist and Sligh (2001) found intelligence was not consistently related to the strength of decoding skills for 65 children with ID not limited to cerebral palsy. Children who were stronger decoders of print were significantly better than weaker decoders of print in language ability, PA, and phonological memory, but did not necessarily have higher IQ scores.

Ehri (2004) described the need to consistently define what is meant by phonological awareness across reading research. As evident in the studies reviewed thus far, this need becomes particularly important when we discuss individuals with ID who may have a range of abilities including a range of speech, language comprehension and vocabulary skills. The measurement tools we use and how we define the skills they assess are of critical importance to make conclusions about the developmental processes at play in reading development. For example, Allor, Mathes, Roberts, Cheatham, and Champlin (2010), in a study with 59 children in 1^{st} – 4^{th} grade with ID, found that children made gains in reading skill and phonological skill, but these changes were not detected by the measures used on the Comprehensive Test of Phonological Processing (CTOPP; Torgesen, Wagner & Rashotte, 1999), but were on the

Dynamic Indicators of Basic Early Literacy Skills (DIBELS). Careful description of participants' skills and the battery of assessments used to elicit their performance is called for to make clear and consistent conclusions about factors important to phonological awareness in children with ID. Barker, Saunders and Brady (2012) highlighted the fact that it is difficult to build a cumulative knowledge base of research findings for children with ID who may have speech impairment given the range of tasks administered across the 26 studies reviewed with participants with IDD and speech impairment. No two studies used the same procedure to assess intelligibility or early literacy skills. There is a need for standardized assessments that can be used across studies with participants with IDD and who may have severe speech impairment. This project aims to assess the use of experimental tasks that cover a range of phonological ability.

1.5 Access to Instruction: Home Literacy

In addition to the intrinsic skills discussed thus far, the importance of home literacy experience should be considered as a contributing factor to phonological awareness and later reading development. In a study that explored typically developing children's understanding of print conventions and the relationship to home literacy experience, 474 children ages 48 to 83 months completed standardized measures of phonological awareness and early reading skills (Levy, Gong, Hessels, Evans, & Jared, 2006). In 4, 5 and 6-year old children, the extent of home literacy activities did not predict phonological awareness ability, but did predict the amount of letter and print knowledge children had. Children with greater involvement in home literacy activities led to greater knowledge about the conventions of print, words and letter names. At 6 years of age, greater home literacy activities led to greater scores on spelling assessments. Levy and colleagues concluded that home literacy experience had the greatest direct impact on children's knowledge of print. This knowledge of print may provide a context to readily apply developing phonological skills which they found were highly correlated with print knowledge, and allow children with greater home literacy experiences an advantage when learning to read. In a study to determine differential effects for rhyme and phoneme awareness as a function of home literacy environment with 40 children between 4 – 6 years of age, Foy and Mann (2003) concluded that the relationship between teaching frequency and phoneme awareness was mediated by vocabulary and letter knowledge. Reading activities also did not predict phoneme awareness independent of letter knowledge. Rhyme awareness was significantly predicted by experience with reading related computer activities however, and was not dependent on letter and vocabulary knowledge. Foy and Mann (2003) concluded that the home literacy environment is complex and multidimensional and includes components of access to reading material and instruction using that reading material. Overall, phoneme awareness is linked with frequency of parental instruction, where basic rhyme awareness is not. Interestingly, they found that the relationship between media related to reading instruction (e.g., TV, computer games) and the development of phoneme and rhyme awareness was different by age. Children closer to 6 years of age benefitted from experience with media for reading instruction while younger children did not.

Home literacy practices and additionally, parent report of literacy skills, were examined in a study that included children with language impairment (Boudreau, 2005). In 37 preschool children with and without language impairment, parent ratings of their children's early literacy skills were found to be consistent with standardized measures assessed directly with their children. Parents with children with language impairment rated their children more poorly across domains of literacy knowledge than parents of children without language impairment. Parents of children with language impairment were found to engage less in book reading and writing with their child than parents of children without language impairment. The home literacy experiences of preschool children who have developmental disabilities and use AAC also have been found to be different from the experiences of their same age peers without disabilities. Opportunity to engage with printed materials and participate in writing or drawing activities was limited compared to same age peers without disabilities (Light & Kelford Smith, 1993). Koppenhaver, Pierce, Steelman and Yoder (1995) reported that children who use AAC systems have 2 out of every 10 experiences that their siblings have with books and basic literacy skills that help to build the foundation of reading. Further research is warranted to understand the home literacy experiences of preschool age with disabilities and a range of speech ability. Questions surrounding the number of books read, engagement with technology during literacy activities and the child's level of engagement during these activities are all relevant areas to examine to allow a better understanding of the components involved in the development of phonological awareness in children with significant speech impairment.

1.6 Access to Instruction: Preschool Literacy

The National Reading Panel (NRP; NICHD, 2000) produced a meta-analysis that examined methods of teaching PA. It found that teaching PA is effective and improves children's ability to manipulate phonemes in speech, a skill that transfers to skills for manipulating phonemes in print. PA instruction is suggested to contribute to children's ability to read and spell for months and years after initial instruction in PA has ended. Activities that ultimately have the greatest impact on children's reading development involve teaching students to manipulate phonemes with letters. Futhermore, small group settings were found to be the most effective context to deliver PA instruction with children. Little information is available currently about the content and context of PA instruction for children with developmental disabilities with limited or significant impairments in speech.

Special education teachers have been found to have a range of perspectives on literacy instruction for students with disabilities and significant speech impairment (Ruppar, Dymond, & Gaffney, 2011). In a survey conducted to evaluate teachers' perspectives on literacy instruction with children with significant speech impairment who used AAC, teachers who taught students across K – 12^{th} grades were found to rate literacy instruction that occured during life-skills-linked lessons more favorably than setting aside specific time to teach foundational skills for reading ability as suggested by the NRP (NICHD, 2000). For example, teachers were more likely to engage in activities involved in matching whole words to common objects and teaching text commonly found in community settings and on signs than engaging in activities of phonological awareness and print decoding (Ruppar, Dymond, & Gaffney, 2011). In a study that looked specifically at the quality of early literacy instruction in preschool classrooms serving students at-risk for later learning or reading disabilities, teachers were found to have low quality of implementation of the reading curriculum materials they were using and failed to systematically and explicitly deliver reading instruction, including phonological awareness activities (Justice, Mashburn, Hamre, & Pianta, 2008). Further research is warranted to determine what instruction is being provided by special education teachers in preschool. Information about the instruction being provided to children with developmental disabilities will allow a better understanding of the factors at play in the development of foundational reading skills for these children.

1.7 Assessment Tasks for Phonological Awareness

A number of tasks have been used in the literature to date to assess phonological awareness. Depending on the particular component of phonological awareness assessed, these tasks lie along a developmental continuum. *Rhyming tasks* use ending rime sounds to ask the child to identify words that rhyme, or sound the same. *Onset-rime manipulation tasks* ask the child to isolate, identify, segment or blend syllables of a word that appear at the beginning (onset) or end (rime). Tasks that assess phonological awareness at the level of the individual phoneme include *phoneme isolation tasks* where the child is asked to identify the first or last sound of a word. *Phoneme identity tasks* ask the child to distinguish the sound that is the same in a string of words. *Phoneme categorization tasks* ask the child to identify a word with a common phoneme among a group of words. *Phoneme blending tasks* require the child to put component phonemes together to make a whole word. *Phoneme segmentation tasks* ask the child to break down a whole word into component phonemes. *Phoneme deletion tasks* ask the child to say the resulting word from a larger word by removing a component phoneme. Inherently, each of these tasks require productive speech output and place retrieval demands on a child's extant vocabulary knowledge.

1.8 Phonological Assessment for Children with Limited Speech

Currently, only experimental assessment tools exist to evaluate phonological skills in children with limitations in speech. Many of these experimental tools only assess one level or type of phonological awareness skill rather than a comprehensive range of skills as in standardized tests such as the Comprehensive Test of Phonological Processing (CTOPP; Torgesen, Wagner, & Rashotte, 1999). Gilliam, Fargo, Foley and Olszewski (2011) developed an experimental phoneme deletion task (e.g., point to the picture of mice without /m/) for individuals with limited speech that includes a dynamic assessment format. Using a dynamic procedure, the examiner is allowed to first teach children what it means to find a picture of a word without its initial sound. After children are able to pass prompted teaching trials, the test is administered. An experimental nonverbal literacy assessment task (NVLA) for children in Kindergarten – fourth grade was developed by Browder and colleagues (2008) that includes components of phonemic awareness and orthographic knowledge. The underlying structure of this assessment was found to have six constructs that reflect emergent literacy skills (Baker, Spooner, Ahlgrim-Delzell, Flowers, & Browder, 2011). These six constructs include phonemic awareness, phonics, comprehension, vocabulary, listening comprehension and text awareness. Browder and colleagues (2008) found gains on phonological awareness assessment tasks using the NVLA in a randomized controlled study of 23 students in K – 4^{th} grades with IDD and a range of speech ability. Vandervelden and Siegel (2001) investigated the use of a series of alternative assessment tasks of phonological awareness in 32 individuals ages 7.5 to 17.5 using three separate types of tasks. The three tasks were: 1- rhyme judgment, 2- phonological recoding using a speech to print matching task and nonword spelling task, and 3- phoneme awareness using a yes/no response to recognition of initial, final, and complex phonemes of a word when presented with a picture. Barker, Bridges and Saunders (2014) developed the Dynamic Assessment of Phonemic Awareness via the Alphabetic Principle (DAPA-AP), a dynamic assessment task that assesses onset, rime, coda and vowel using printed orthography and requires no speech output. Recently, Preston and Edwards (2010) developed an experimental PA assessment that does not require a spoken response in order to assess PA in children with speech-sound disorders. Phonological skills that were assessed include rhyme matching, onset segmentation, onset matching, onset-rhyme blending, and blending of individual phonemes to make a word. With recent advances in experimental tools to assess phonological awareness in children with limited speech ability, more research is warranted using these tools with children with IDD as early as preschool.

2 PROJECT AIMS

The purpose of this study is to identify key intrinsic and extrinsic factors that are related to the development of phonological awareness in children between 4-5 years of age with developmental disabilities. The first aim is to systematically assess and describe children's intrinsic factors of speech ability, receptive language, cognitive skills and phonological awareness. The second aim of this project is to describe the extrinsic factors of home and school literacy instruction provided to children with developmental disabilities to determine key extrinsic factors related to phonological awareness. The third and final aim is to determine the amount of variance in phonological awareness skill that may be explained by the intrinsic factors of auditory discrimination, orthographic knowledge and speech ability. Given the aims of this study, 5 specific research questions were developed in order to make conclusions regarding the intrinsic and extrinsic factors related to the development of phonological awareness in children between 4 – 5 years of age with developmental disabilities.

2.1 Questions

2.1.1 Question 1.

What are the profiles of phonological awareness, orthographic knowledge, cognitive ability, receptive language, receptive vocabulary, auditory discrimination and speech ability in children with developmental disabilities?

It is hypothesized that profiles for each variable will be positively skewed such that there will be a greater amount of low performance on average across measures than average performance across measures.

2.1.2 Question 2.

What is the relationship between phonological awareness, orthographic knowledge, cognitive ability, receptive language, receptive vocabulary, auditory discrimination and speech ability in children with developmental disabilities?

It is hypothesized that a strong, positive relationship will be found between phonological awareness, receptive vocabulary, auditory discrimination and speech ability.

2.1.3 Question 3.

What is the relationship between home literacy experience, phonological awareness, orthographic knowledge and speech ability in children with developmental disabilities?

It is hypothesized that a strong, positive correlation will be found between home literacy experiences, orthographic knowledge and speech ability. Children with less speech ability will have less engagement in home literacy activities than children with more speech ability.

2.1.4 Question 4.

What is the relationship between preschool literacy instruction, phonological awareness, orthographic knowledge and speech ability in children with developmental disabilities?

It is hypothesized that a strong, positive correlation will be found between preschool literacy instruction, orthographic knowledge, phonological awareness and speech ability. Children with less speech ability will have less experience with preschool literacy instruction.

2.1.5 Question 5.

What is the relationship between phonological awareness, orthographic knowledge, auditory discrimination and speech ability in children with developmental disabilities?

After controlling for age and cognitive ability, orthographic knowledge and auditory discrimination, it is hypothesized that speech ability will be a significant predictor of phonological awareness in children with developmental disabilities.

3 METHOD

3.1 Study Design

A non-experimental study design was used to examine the relationship between a range of variables, intrinsic and extrinsic, to phonological awareness in children with developmental disabilities between the ages of 4;0 and 5;09 years. All participants completed a series of assessments that measured intrinsic factors of speech ability, cognitive skills, language ability, auditory discrimination skill, letter knowledge and phonological awareness. Each child's primary caregiver was asked to complete a questionnaire of home and school literacy instructional experiences to measure extrinsic factors. Relationships between intrinsic and extrinsic factors to phonological awareness were examined across the entire group of participants. Control over the order of administration of measures was counterbalanced using a Latin square design. The age range of 4 – 5 years was chosen because this is the age when typically developing children are able to complete tasks of phonological awareness and begin phonological awareness instruction in preschool. Potential implications of this study's results could have an important impact on PA instruction for children in preschool with developmental disabilities who have and do not have limitations in speech.

3.2 Participants

Forty-two children between the ages of 4 years and 5.75 years (M = 4.74 years, SD = 6.36) with developmental disabilities and a range of speech ability were recruited. Participants who met state criteria and district eligibility for enrollment in preschool special education services under the Individuals with Disabilities Education Act (IDEA) Part B and received a score of at least 2SD below average on one or more of the subtests of the Mullen Scales of Early Learning (Mullen; Mullen, 1995) were included. Approval was granted from a local metro Atlanta area school district to recruit participants along with approval from 9 private preschool programs for children with developmental disabilities and metro Atlanta area clinics and recreational programs for children with developmental disabilities. Parental consent for participation in the study was obtained by distributing consent forms to 12 special education pre-Kindergarten classrooms across 9 elementary schools. Twenty-four children across the 9 elementary schools returned consent forms to allow his/her participation in the study. These 24 children were seen for direct assessment in their local preschool in a separate room nearby their classroom free of distraction. Nine of the 42 children were recruited for participation from three private preschool programs in the metro Atlanta area serving children with developmental disabilities. These 9 children were seen for direct assessment in their preschool in a separate room nearby their classroom. The remaining 9 of 42 children were recruited from metro Atlanta area clinics and recreational programs for children with developmental disabilities. Seven children were seen at the recreational center where they were recruited and 2 children traveled to Georgia State University where they were seen in a research laboratory setting.

Three of the 42 children were a set of triplets, and 2 other participants of the total 42 children were siblings. Twenty-one children were African American, 1 child was Asian, 17 were Caucasian, 2 were multi-racial, and 1 identified as other race. Twenty-nine children were male and 12 were female. Seventeen children had a diagnosis of Autism Spectrum Disorder, 7 were diagnosed with global developmental delay, 6 had Down syndrome, and 6 had specific diagnoses of Fragile X Syndrome, Phelan McDermid Syndrome, Smith-Magenis Syndrome, Angelman Syndrome, Tuberous Sclerosis Complex and Histiocytosis. Three children's parents reported unknown etiology and three children's parent (parent of the triplets) did not return the demographic survey to report diagnosis.

Recruitment targeted children with a range of speech ability from limited impairment in expressive speech to significant impairment in expressive speech ability. Table 1 describes children's speech characteristics as measured by the Kaufman Speech Praxis Test (KSPT, Kaufman, 1995), an assessment used to measure oral motor skill (part 1), motor speech production (parts 2 and 3) and speech intelligibility (part 4).

Table 1 ***Mean Raw, Standard Scores, Range and Confidence Intervals on the Kaufman Speech Praxis Test***

Measure	Raw Mean(SD)	Range	CI 95%	Standard score Mean(SD)	Range	CI 95%
Kaufman Part 1	8(3.90)	0 – 11	±1.18	82.17(35.47)	2 – 111	±10.73
Kaufman Part 2	44.40(24.51)	0 - 63	±7.41	66.43(49.50)	1 - 113	±14.97
Kaufman Part 3	38.07(30.41)	0 - 80	±9.2	87.62(30.67)	45 – 129	±9.28
Kaufman Part 4	3.57(2.62)	0 - 7	±0.79	94.60(18.75)	61 - 121	±5.67

Note. N = 42; CI = Confidence Interval; SD = Standard deviation; Kaufman = Kaufman Speech Praxis Test (KSPT, Kaufman, 1995). Mean Standard Scores are reported are from the normative sample of children with speech impairments in the KSPT.

Speech intelligibility as measured by the KSPT part 4 for children ranged from 0 (complete unintelligibility) to 7 (complete intelligibility) with a mean of 3.57 (SD = 2.62) (decodable). Three children had oral motor apraxia, 15 had a range of mild to severe verbal apraxia, 7 had speech sound (articulation) disorders, 8 children had dysarthria of speech with a range from mild to severe (6 children had flaccid dysarthria and 2 had mixed flaccid/spastic dysarthria) and 9 had no speech disorder. Seventeen children used speech in sentences, 8 children used short phrases, 7 children used only single words for communication, 8 children primarily communicated using either gestures, vocalizations or physical touch/manipulation, and 2 children used a SGD AAC system as a primary means of communication.

Participants had a range of language ability, and evidenced intentional communication in at least one modality of speech, gesture, sign or use of visual-graphic symbols on an AAC system. All participants had upper extremity motor skills necessary for direct selection of pictures on an easel or computer touchscreen as a response during test administration. Children were excluded if they met school district eligibility under the categories of deafblind, deaf/hard of hearing, emotional and behavioral disorder and visual impairment or had English as a second language. An a priori power analysis was conducted using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) and confirmed that the proposed number of participants with medium to large effect sizes was sufficient for each of the data analyses.

3.2.1 Parents.

One parent of each child completed home and school literacy surveys to describe his/her own reading experiences and preferences and provide information about extrinsic factors of literacy instruction for their son/daughter. A total of 38 parents (including 1 grandparent who was the child’s legal guardian) completed surveys. The average age of each child’s participating parent was 38.40 years of age (SD = 9.15, range = 21.53 – 72.94). One parent was male, 37 parents were female. Thirty-five of the 37 parents reported their education level. Ten parents had at least a high school education, 4 parents had at least associate degrees, 11 parents had at least a bachelor’s degree, 7 had Master’s degrees and 3 had doctoral degrees.

3.3 Setting

Assessment took place at the participant's school, community location where recruitment took place. Two participants were seen at a research laboratory at Georgia State University. After agreeing to participate in the study, one parent completed a consent form that allowed his/her child to participate in the study. Assent was obtained from the child by continuously monitoring his/her willingness to participate throughout the entire assessment process. A single examiner, the primary author, conducted all direct assessment with children in the study. At least two assessment sessions, and sometimes a third was conducted with each child. Assessment sessions ranged from 30 minutes to 1 hour and a half each depending on the child's ability to sustain a meaningful level of engagement with the task as judged by the examiner. Breaks were incorporated as necessary for each child to remain attentive to the assessment tasks. In the event a child was not able to attend long enough to complete all of the measures planned for each session, a third visit was scheduled to complete the remaining tasks. All assessment sessions were completed in no longer than two weeks.

3.4 Assessment Measures

A series of standardized and experimental measures were used. Table 2 summarizes each measure that was used, the skills it assessed and estimated time of administration. Assessment measures consisted of parent report and direct assessment with each child. A graduate speech-language pathology student trained in the assessment tools administered scored 20% of the assessments to check for the reliability of raw and standard score calculations. A reliability of 0.98 was found by dividing the number of agreements by the number of agreements plus disagreements.

Table 2 ***Assessment Measures***

Measure	Skill/s Assessed	Time (mins)	Parent Report	Standardized Assessment	Experimental Measure
Initial Visit					
Kaufman Speech Praxis Test (KSPT; Kaufman, 1995)	Speech Ability	5 – 15		X	
Mullen Scales of Early Learning (Mullen; 1995)	Cognitive ability, Receptive & Expressive language, Fine motor skills	40 – 60		X	
Peabody Picture Vocabulary Test-IV (PPVT; Dunn & Dunn, 2007)	Receptive Vocabulary	10 – 15		X	
Non-speech Phonological Awareness Assessment Tasks (Preston & Edwards, 2010)	rhyme matching, onset segmentation, onset matching, onset-rhyme blending, and blending of individual phonemes	20 - 30			X
Phonological Awareness Literacy Screening-PreK (PALS-PreK; Invernizzi, Sullivan, Meier, & Swank, 2004 .) Section IV: Print and Word Awareness	Conventions of print within the context of a book	10		X	
Phonological and Print Awareness Scale (PPA; Williams, 2014) Subtest II: Print Knowledge Subtest V: Sound-Symbol	Uppercase and Lowercase Letter Identification, Letter-sound identification	10		X	
Wepman's Auditory Discrimination Test (ADT; Wepman & Reynolds, 1987)	Auditory discrimination of minimal pair phonemes in speech	10-15		X	
Home and School Literacy Questionnaire	Home and School Literacy environment	10	X		

3.4.1 Speech Assessment.

The Kaufman Speech Praxis Test for Children (KSPT; Kaufman, 1995) was used to assess oral motor skills and speech ability. The KSPT is a standardized assessment tool that assists in the diagnosis and treatment of developmental apraxia of speech in preschool children and is comprised of a normative sample of children ages 2;0 to 5;11 years. Administration time took between 5 and 15 minutes. The KSPT allows for precise identification and description of children's motor speech proficiency using imitative responses across 4 subtests. Subtest 1 elicits information about the child's ability to imitate oral motor movements such as opening their mouth, moving their tongue left to right, and puckering their lips. Subtest 2 elicits imitation of a range of speech sounds beginning with a series of pure vowel sounds in isolation (e.g., /I/ as in 'hit'), progressing to vowel to vowel movement (e.g., /aI/ as in 'high'), consonant production in isolation (e.g., /m/) and continues to elicit an increasingly more difficult series of vowel (V) to consonant (C) movement imitation tasks (e.g., imitation of CVCV words such as 'mama', CV1CV2 words such as 'bubble') that culminate in the ability to imitate words that have C1V1C2V2 structure (e.g., the word 'happy'). Subtest 3 elicits imitation of complex consonant productions such as consonant blends (e.g., /s/ blends such as 'swing', /r/ blends such as 'frog') and complex polysyllabic words that involve CVCVCV sequencing such as 'banana', 'invitation' and the rapid and accurate production of the nonsense word /pʌtəkə/. Subtest 4 allows the rater to score the child's spontaneous speech on a scale of 0 to 7 as completely unintelligible, decodable or completely intelligible. Descriptive information is collected about the child's spontaneous speech at this level and compared to elicited speech sounds in isolation on prior subtests. Children were initially administered only parts 1, 3 and 4. If a child was unable to complete part 3, part 2 was administered. A raw composite score to describe motor speech ability was derived for each child by adding raw scores of parts 2 and 3 for the KSPT. Raw scores for speech intelligibility were determined by part 4.

It is important to note that in the normal sample on the KSPT, the average standard score of 100 on subtests of the KSPT is not equal to the average percentile rank of 50. The underlying distributions of the standardization sample for the KSPT are not normal distributions and follow a negative skew (Kaufman, 1995). When standardizing the KSPT, typically developing children often passed most or all of the items for the age group on the scale, reaching a point where no more improvement could be measured by the test. The resulting measurement scale for the test creates raw scores that can differ by one point, while their corresponding standard scores can differ by 20 points. For example, for children between 55 and 60 months of age, a raw score of 62 provides a standard score of 49 and percentile ranking of 2, however a raw score only one point higher of 63 (the maximum raw score possible), provides a standard score of 104 and percentile ranking of 10. The disordered sample of the KSPT consists of 263 children identified as speech impaired by a speech-language pathologist. Normative data for the disordered sample provided a greater range of standard scores compared to raw scores on the KSPT for comparison to the children in this study. The standard scores reported in Table 1 were taken from the disordered sample norms of the KSPT.

While the KSPT does not determine dysarthria in children, information about intelligibility and oral motor movement ability are provided. The KSPT elicited oral motor movements and speech from the child that could be observed for characteristics of dysarthria. A supplemental checklist of symptoms of dysarthria adapted from Yorkston, Beukelman, Strand and Bell, (1999) was used to identify children who have dysarthria. See Appendix A for the supplemental checklist.

3.4.2 Auditory Discrimination.

Wepman's Auditory Discrimination Test, 2nd edition (ADT; Wepman & Reynolds, 1973) was used to assess children's auditory discrimination skills. The ADT measures the ability of children to discriminate 40 different word pairs differing by one phoneme. Thirteen word pairs differ in their initial consonant (e.g., coast/toast), 4 word pairs differ in their medial vowel (e.g., pat/pet), 13 word pairs differ in their final consonant (e.g., lease/leash) and 10 contain identical word pairs (e.g., jam/jam). The ADT took between 5 – 10 minutes to administer. Standardized scores are provided based on a sample of 2,000 children 4 – 8 years of age. This assessment was modified for presentation on a computer touchscreen where the child heard a standard audio recording of the examiner present each pair of words and were asked to answer yes or no using an interactive touchscreen. Practice items were provided prior to assessment using pairs of non-speech pictures (e.g., apples, bananas), auditory sounds (e.g., dog barking/bell ringing) and minimal pair words to ensure that children could provide an accurate yes/no response prior to assessing their ability to discriminate between minimal pairs of spoken test items. If a child did not provide chance performance for practice items, administration did not continue to test items.

3.4.3 Cognitive, Language and Motor Ability.

The Mullen Scales of Early Learning (Mullen; Mullen, 1995) was used to assess cognitive, language and motor ability across five scales: gross motor, visual reception, fine motor, expressive language and receptive language. The Mullen reports standardized scores for children birth to 68 months of age. Average time to complete the assessment for all children was between 40 – 60 minutes. The Mullen provides normalized T scores (M = 50, SD = 10), percentile rankings and age equivalent scores for each of the 5 scales along with an overall early learning composite (M = 100, SD = 15). With the exception of the expressive language subscale, the Mullen relies very little on a spoken response to assess receptive language, visual reception and fine motor skills making it appropriate to use with the children in this study. The gross motor subtest was not administered given that gross motor skills are not a variable of interest relevant in this study. Furthermore, age equivalent scores for the gross motor subtest are available only up to age 33 months. A raw composite score of developmental skill was derived by adding the raw scores of the subtests of visual reception, fine motor, and receptive language to use in data analyses. The standardization sample includes 1,849 children between 1 and 69 months of age across 4 geographic regions (Northeast, Sout, West, and North and South Central) of the United States to ensure a diverse sample of race, ethnicity and socioeconomic status representative of the population. Children with known disabilities were not included in the standardization sample.

3.4.4 Receptive Vocabulary.

The Peabody Picture Vocabulary Test (PPVT-IV; Dunn & Dunn, 2007) was used to assess single word receptive vocabulary. The PPVT-IV provides standardized comparisons for children age 2;6 through adulthood. Administration time took between 10 – 20 minutes. The standardization sample includes 3,540 individuals between 2 years 6 months of age through 90 years of age across 320 sites in the United States deemed representative of the population. Additionally, a sample of children between 3 and 7 years of age with language delays (n = 63) were collected for comparison and scored on average 10 standard score points below the typically developing comparison sample.

3.4.5 Conventions of Print and Letter Knowledge.

Phonological Awareness Literacy Screening-PreK (PALS-PreK; Invernizzi, Sullivan, Meier, & Swank, 2004) and the *Phonological and Print Awareness Scale* (PPA; Williams, 2014) were used to assess early literacy skills related to conventions of book reading and letter knowledge. The PALS-PreK is an assessment of early literacy skills including rhyme, beginning sound matching, alphabet knowledge, print and word awareness and name writing for children 4 years of age and in Pre-Kindergarten. Raw score comparisons using a standard sample of Pre-K children are provided for each subtest. Section IV: Print and Word Awareness was administered. The print and word awareness subtest assessed knowledge about the conventions of print within the context of a book. Children were presented a rhyming book Hey Diddle Diddle. Ten items were administered using a standard script from the PALS-PreK to elicit information from the child about his/her knowledge of literacy broadly. Children were asked to find the title of the book, point to separate words, match words, show their understanding of the directionality of print, identify letters in a sentence, and point to words spoken by the examiner. The maximum raw score for this subtest is 10, with average raw scores for children in PreK between 7 - 9. The standardization sample for the PALS-PreK includes children from public, private and head start pre-K programs across the Virginia Commonwealth district and does not include children with developmental disabilities. The 2003–2004 pilot of the PALS-PreK determined inter-rater reliability and concurrent validity when used with for males and females across a diverse sample of school programs (i.e., public, private, and Head Start) and ethnicity.

The Phonological and Print Awareness Scale (PPA; Williams, 2014) was used to measure early literacy skills of print knowledge and sound-symbol identification. It is standardized with children between 3 years 6 months and 8 years 11 months of age and required between 10 and 15 minutes to administer. A multiple-choice format was used for each subtest so that a spoken response was not required. The examiner read the instructions to the child and the child pointed to his/her answer. Subtests II: Print Knowledge, and subtest V: sound-symbol identification were used to assess orthographic knowledge. Subtest II assessed print knowledge by evaluating the child's ability to identify uppercase and lowercase letters. Subtest V evaluated the child's ability to identify phonemes (sounds) that matched corresponding letters in the initial and final position of words.

3.4.6 Phonological Awareness.

Phonological awareness was assessed using experimental assessment methods as described by Preston and Edwards (2010). Experimental measures from Preston and Edwards (2010) were presented to participants using a touch screen tablet device. Four pictures were presented on the touch screen for the child to choose from. A standard recording was presented to the child prior to and throughout each subtest to identify the target word or phoneme/s the child is to choose or blend from the array of pictures. Each photo was named prior to the child's selection of the correct answer to ensure he/she had the opportunity to pair the word representing each picture. Phonological skills that were assessed included rhyme matching (e.g., "Which one rhymes with Dan?") onset segmentation (e.g., "Which one begins like Tom?"), onset matching (e.g., "Which one begins with /p/?"), onset-rhyme blending (e.g., "Which one is a picture of /f – I ʃ/?") and blending of individual phonemes (e.g., "Which one is a picture of /f – I- ʃ/?"). Raw scores were calculated for each subtest. An overall composite score was calculated by adding scores across each subtest.

3.4.7 Family Demographic Form.

Each child's primary caregiver completed a family demographic form that included information about his/her child's medical history, ethnicity, and their own educational achievement and employment to generate information about socioeconomic status (SES) for descriptive purposes of the participants. Appendix B contains the family demographic form that was used. This demographic form is adapted from the one used in the toddler language intervention study reported by Romski et al. (2010).

3.4.8 Home and School Literacy Questionnaire.

Each child's primary caregiver also completed a home and school literacy survey developed for this study (Barton-Hulsey & Sevcik, 2016) and drawn from Boudreau (2005), Dynia, Lawton, Logan and Justice (2014), Light & Kelford Smith (1993), Peeters, Verhoeven, de Moor, van Balkom and van Leeuwe (2009), Rashid, Morris and Sevcik (2005) and Ruppar, Dymond and Gaffney (2011). The survey provided information about both the home and school literacy experiences of the child. The home literacy portion of the survey provided information about the literacy environment and activities the child and parent regularly engage in. The school literacy portion of the survey provided information about the type of classroom setting (i.e., inclusive general education, special education) the child was in and specific information on the type and frequency of literacy instruction that occurred in the classroom setting. Appendix C contains the home and school literacy survey that was used.

4 RESULTS

4.1 Question 1

What are the profiles of phonological awareness, orthographic knowledge, cognitive ability, receptive language, receptive vocabulary, auditory discrimination and speech ability in children with developmental disabilities?

Table 3 reports mean raw and standard scores, standard deviations, distributions and confidence intervals for all direct assessment measures of developmental skills, language, vocabulary and speech ability for the 42 children. Table 4 reports mean raw scores, standard deviations, distributions and confidence intervals for all direct assessment measures of early reading skills including print and word awareness, orthographic knowledge, phonological awareness and speech perception.

Children in this study evidenced a range of skill in all areas of direct assessment. There was greater variability in measures of developmental skills assessed by the Mullen (visual reception, fine motor skills, receptive and expressive language), receptive vocabulary assessed by the PPVT-IV and speech ability assessed by the KSPT described in Table 3; and less variability in early reading skills described in Table 4 noted by smaller confidence intervals and standard deviations. Only 4 of 42 children were able to complete the Wepman auditory discrimination task with a raw score above 0. Children with a range of receptive language skills had difficulty understanding the instructions of the task. The task required children to answer yes/no when asked if two words sounded the same. Children who were inconsistent in response to practice items and did not pass with greater than 50% accuracy were not administered the full task.

Table 3 ***Children's Performance on Measures of Developmental, Language, Vocabulary and Speech Assessments***

Measure	Raw Mean(SD)	Range	CI 95%	Standard score Mean(SD)	Range	CI 95%
Mullen Scales of Early Learning						
Visual Reception	38.43(9.20)	20 – 60	±2.78	33.24(15.11)	<20 – 74	±4.75
Fine Motor	33.60(8.19)	19 – 49	±2.48	27.43(12.47)	<20 – 67	±3.77
Receptive Language	31.24(8.81)	14 – 48	±2.66	28.00(13.09)	<20 – 67	±3.96
Expressive Language	28.52(9.90)	6 – 50	±2.99	26.55(9.73)	<20 – 57	±2.94
Early Learning Composite	131.79(33.37)	64-197	±10.09	63.48(17.34)	48 – 105	±5.24
Peabody Picture Vocabulary Test-IV	45.67(26.71)	0 - 129	±8.80	73.60(23.23)	20 – 128	±7.03
Kaufman Part 1	8(3.90)	0 – 11	±1.18	82.17(35.47)	2 – 111	±10.73
Kaufman Part 2	44.40(24.51)	0 - 63	±7.41	66.43(49.50)	1 - 113	±14.97
Kaufman Part 3	38.07(30.41)	0 - 80	±9.2	87.62(30.67)	45 – 129	±9.28
Kaufman Part 4	3.57(2.62)	0 - 7	±0.79	94.60(18.75)	61 - 121	±5.67

Note. N = 42; CI = confidence interval; SD = standard deviation; SS = standard score; Mullen (Mullen; 1995) subscales are based on a mean of 50 and standard deviation of 10; Peabody Picture Vocabulary Test-IV (Dunn & Dunn, 2007) scores are based on a mean of 100 and standard deviation of 15. Mean Standard Scores are reported are from the normative sample of children with speech impairments in the KSPT (Kaufman, 1995).

Table 4 ***Children's Performance on Measures of Early Reading skills of Print and Word Awareness, Letter and Sound-Symbol Awareness, Phonological Awareness and Speech Perception***

Measure	Raw Mean(SD)	Range	CI 95%	Maximum Score
PALS Pre-K	4.12(2.91)	0 - 9	±0.88	10
PPA letter knowledge	8.43(4.70)	0 - 16	±1.42	17
PPA sound-symbol	3.21(3.03)	0 - 11	±0.92	11
Phonological Awareness				
Rhyme matching	4.43(3.30)	0 – 15	±1	16
Onset segmentation	2.33(2.23)	0 – 10	±0.67	10
Onset matching	2.71(2.62)	0 – 10	±0.79	10
Onset-rhyme blending	1.86(1.54)	0 – 4	±0.47	6
Phoneme blending	1.81(1.52)	0 – 6	±0.46	6
Composite Score	13.14(8.81)	0 – 40	±2.66	48
Wepman ADT	1.33(4.69)	0 - 26	±1.42	30

Note. N = 42; CI= confidence interval; SD = standard deviation; PALS = Phonological Awareness Literacy Screening-PreK (Invernizzi et al., 2004); PPA = The Phonological and Print Awareness Scale (Williams, 2014); ADT = Auditory Discrimination Task (Wepman & Reynolds, 1973).

4.2 Question 2

What is the relationship between speech ability and phonological awareness, print and word awareness, letter knowledge, sound-symbol awareness, receptive language, receptive vocabulary and auditory discrimination in children with developmental disabilities?

Phonological awareness scores were evaluated to determine if a combination of raw scores from subtests of the phonological awareness experimental assessment task (Preston & Edwards, 2010) could be used to represent a composite score for phonological awareness. Table 5 presents a summary of correlations for each subtest of phonological awareness. Medium to large significant correlations were found between all subtests of phonological awareness except for the correlation between the subtest *blending individual phonemes* and *rhyming*.

Table 5 ***Summary of Pearson Correlations, Means, Standard Deviations and 95% Confidence Intervals for Scores on the Experimental Non-Speech Phonological Awareness Assessment Tasks***

Measure	*1*	*2*	*3*	*4*	*5*	*6*
1. Rhyming	-					
2. Onset Segmentation	0.54**	-				
3. Onset Matching	0.48**	0.72**	-			
4. Onset Rime Blending	0.65**	0.51**	0.50**	-		
5. Blending Phonemes	0.24	0.53**	0.51**	0.32*	-	
6. Composite Score	0.81**	0.85**	0.83**	0.75**	0.60*	-
M	4.43	2.33	2.71	1.86	1.81	13.14
SD	3.30	2.22	2.62	1.54	1.52	8.81
95% CI	±1	±0.67	±0.79	±0.47	±0.46	±2.66

Note. N = 42; $**p < 0.01$, $p < 0.05$.

Principal components analysis was run to determine if all subtest items were suitable for combining into one composite score of phonological awareness. The overall Kaiser-Meyer-Olkin (KMO) measure was .782 and Bartlett's Test of Sphericity was statistically significant ($p = .000$) indicating that the data were likely factorizable. PCA revealed one component with an eigenvalue greater than 1 and explained 60.49% of the total variance. Visual inspection of the scree plot confirmed one component should be retained. All subtests loaded on one component at .649 or above. Chronbach's alpha for the 5 subtests was 0.809. A composite raw score for phonological awareness was derived by adding all subtest scores of phonological awareness and was used in further data analyses.

A Pearson partial correlation analysis was conducted to examine the relationship between phonological awareness, each of the Mullen subtests of developmental skill, speech ability, early reading measures of print and word awareness, letter knowledge and sound-symbol awareness, receptive vocabulary and auditory discrimination. Table 6 presents a summary of correlations between raw scores for each measure with means, standard deviations and 95% confidence intervals. Medium to large significant correlations were found between phonological awareness and all other measures.

Table 6 ***Summary of Pearson Correlations Between Direct Assessment Measures of Phonological Awareness, Developmental Skills, Print and Word Awareness, Letter Knowledge, Sound-Symbol Awareness, Receptive Vocabulary, Auditory Discrimination and Speech Ability***

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1. PA composite	-										
2. Visual Reception	.451	-									
3. Fine Motor	.499	.776	-								
4. Receptive Language	.458	.842	.735	-							
5. Expressive Language	.660	.816	.782	.866	-						
6. Speech ability	.457	.821	.729	.822	.908	-					
7. PALS Pre-K	.548	.743	.695	.716	.828	.805	-				
8. PPA Print Knowledge	.531	.664	.629	.606	.671	.602	.557	-			
9. PPA Sound Symbol	.595	.369	.417	.341	.451	**.299**	.443	.569	-		
10. PPVT-IV	.617	.766	.747	.857	.858	.775	.791	.675	.547	-	
11. Wepman ADT	.563	**.247**	.427	.330	.364	**.198**	**.257**	.352	**.295**	.502	-
M	13.14	38.43	33.60	31.24	28.52	82.48	4.12	8.43	3.21	45.67	1.33
SD	8.81	9.21	8.19	8.81	9.90	53.07	2.91	4.70	3.03	26.71	4.69
95% CI	±2.66	±2.79	±2.48	±2.66	±2.99	±16.05	±0.88	±1.42	±0.92	±8.80	±1.42

Note. N = 42. Correlations in bold are non-significant. All other correlations were significant at $p = 0.05$ or below. CI = confidence interval; Speech ability = Kaufman Speech Praxis Test Part 2 and Part 3 raw composite (Kaufman, 1995); PALS = Phonological Awareness Literacy Screening-PreK (Invernizzi et al., 2004); PPA = The Phonological and Print Awareness Scale (Williams, 2014); PPVT-IV = Peabody Picture Vocabulary Test, 4th edition (Dunn & Dunn, 2007); ADT = Auditory discrimination task.

Scatterplot matrices with 95% confidence intervals are presented in Figure 1 to describe the linear relationships between phonological awareness and receptive language, receptive vocabulary, speech ability and Mullen raw score. Upon visual inspection of the scatterplots, it should be noted that while there is a statistically significant relationship between phonological awareness and all other measures of developmental skills, phonological awareness appears to have a stronger linear relationship with developmental skills measured by the Mullen (R^2 = .318) than it does with speech ability (R^2 = .209). Additionally, Scatterplot matrices with 95% confidence intervals are presented in Figure 2 to describe the linear relationships between phonological awareness and early reading measures of the PALS Pre-K, the PPA scale: Print Knowledge and the PPA scale: sound-symbol awareness. Phonological awareness had a similar linear relationship with each of these measures.

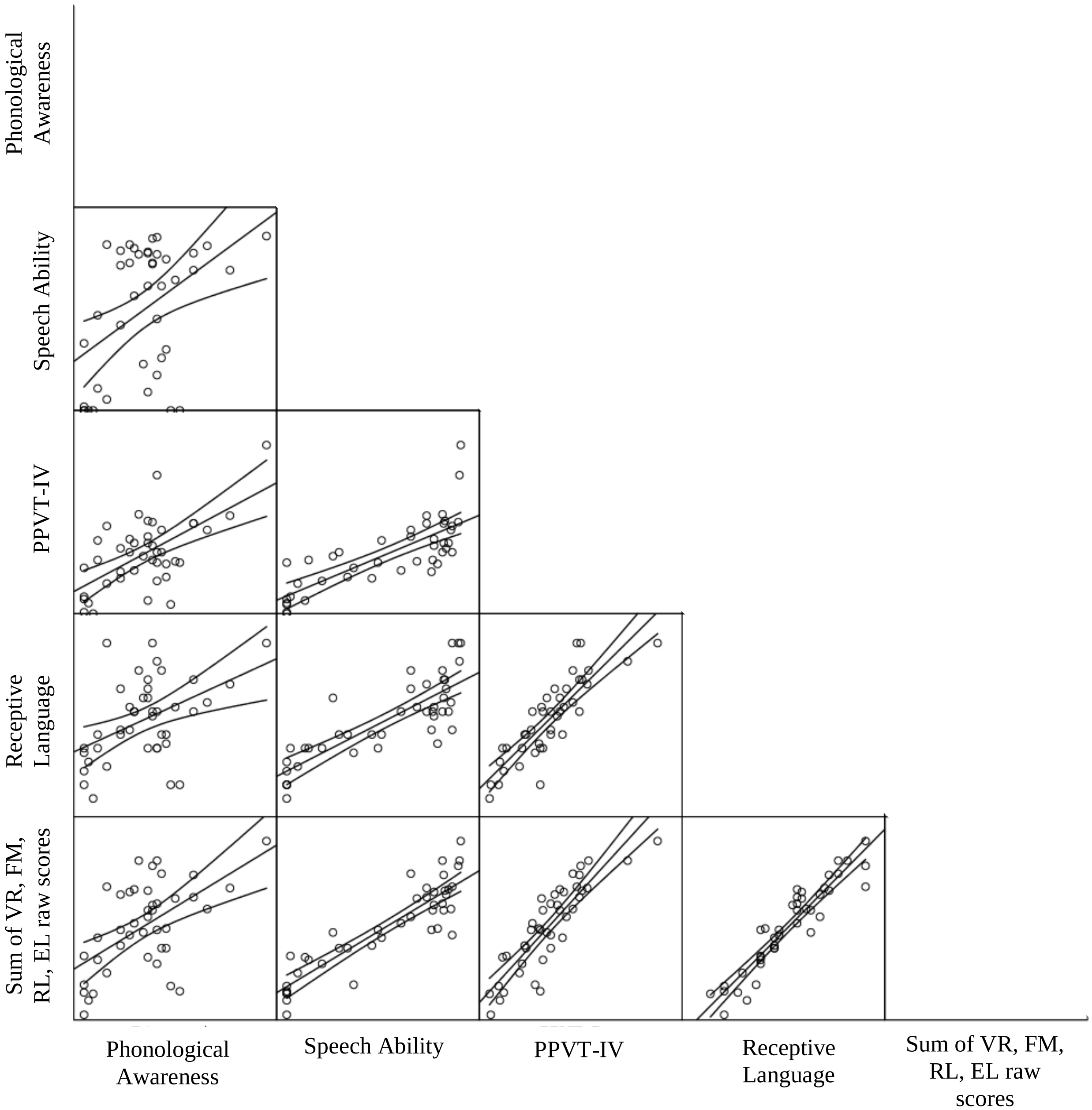

Figure 1. Scatterplot matrices with 95% confidence intervals for phonological awareness, speech ability, Receptive Vocabulary, Receptive Language and Mullen Raw score. Speech Ability = Kaufman Speech Praxis Test Part 2 and Part 3 raw composite score (Kaufman, 1995); PPVT-IV = Peabody Picture Vocabulary Test, 4th edition (Dunn & Dunn, 2007); Receptive Language = Receptive Language subtest, Mullen Scales of Early Learning; VR = Visual Reception, FM = Fine Motor, RL = Receptive Language, EL = Expressive Language subtests of the Mullen Scales of Early learning. N = 42.

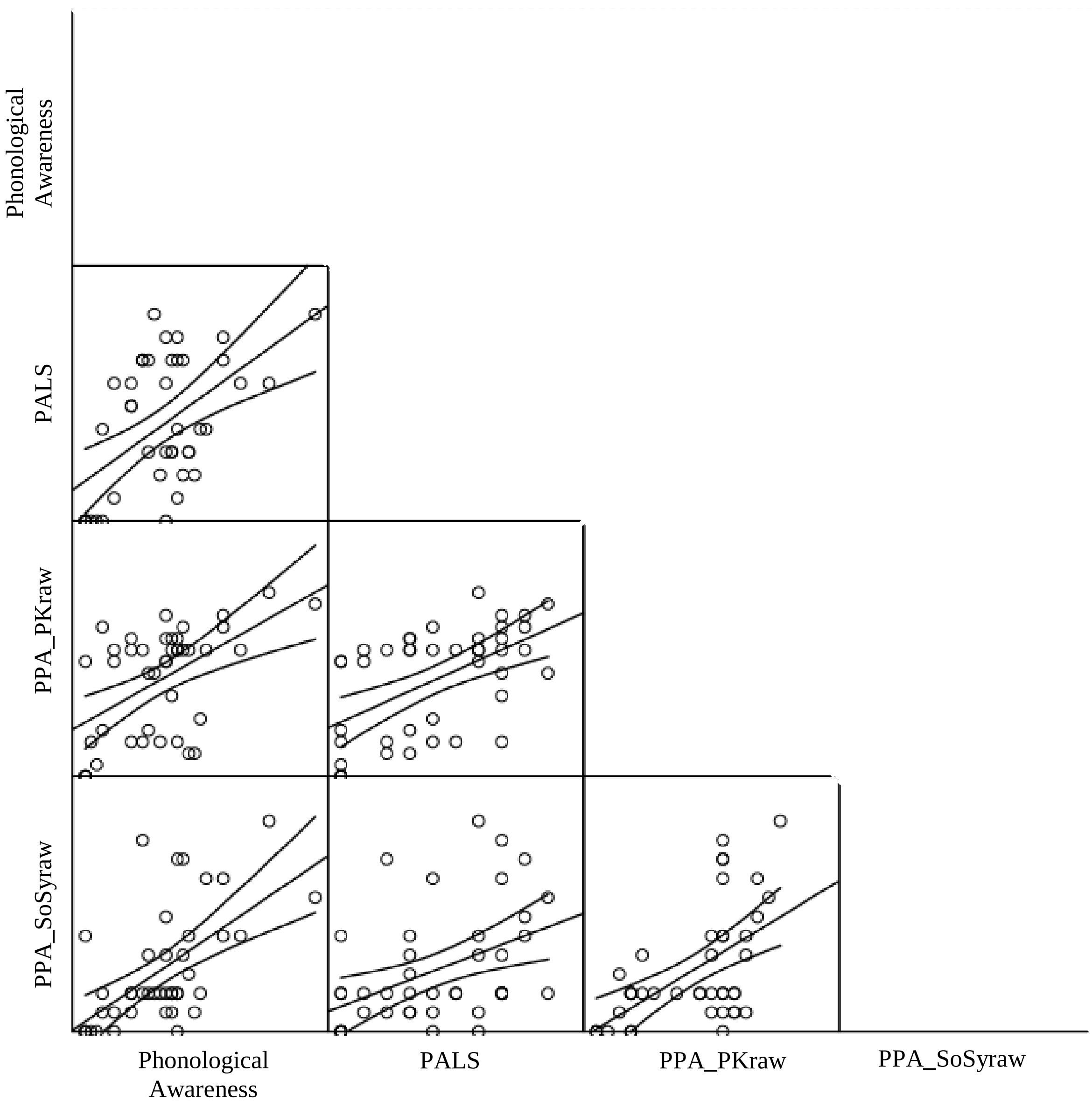

Figure 2. Scatterplot matrices with 95% confidence intervals for phonological awareness, Print and Word awareness, Print Knowledge and Sound-Symbol Awareness. PALS = Phonological Awareness Literacy Screening-PreK (Invernizzi et al., 2004); PPA_PKraw = The Phonological and Print Awareness Scale: Print Knowledge (Williams, 2014); PPA_SoSyraw = The Phonological and Print Awareness Scale: Sound-Symbol Awareness (Williams, 2014). N = 42.

Speech ability had medium to large significant correlations with all measures except sound-symbol awareness and auditory discrimination. Low, non-significant correlations were found between measures of speech ability and sound-symbol awareness and speech ability and auditory discrimination. Low, non-significant correlations between these measures may be due to floor effects on measures of both sound-symbol awareness and auditory discrimination. Children with a range of speech ability performed largely in the low range of ability for both sound-symbol awareness and auditory discrimination. Scatterplots with 95% confidence intervals are presented in Figures 3 and 4 to describe the relationship between speech ability and sound-symbol awareness and speech ability and auditory discrimination respectively. Figures 5, 6 and 7 present a scatterplots with 95% confidence intervals to describe the relationship between speech ability and phonological awareness, speech and print/word awareness, and speech and print knowledge.

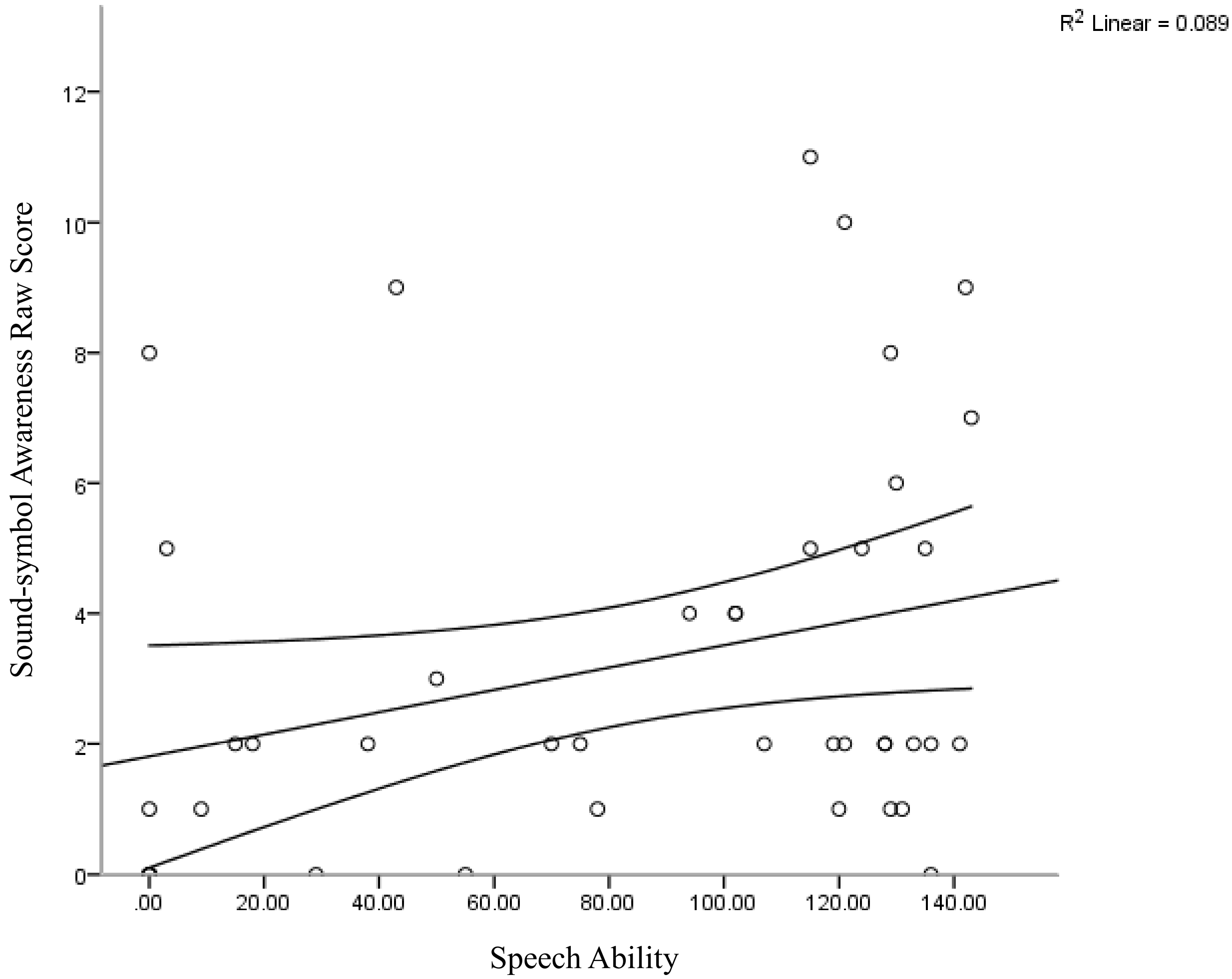

Figure 3. Scatterplot with 95% confidence intervals for speech ability and sound-symbol awareness scores. N = 42.

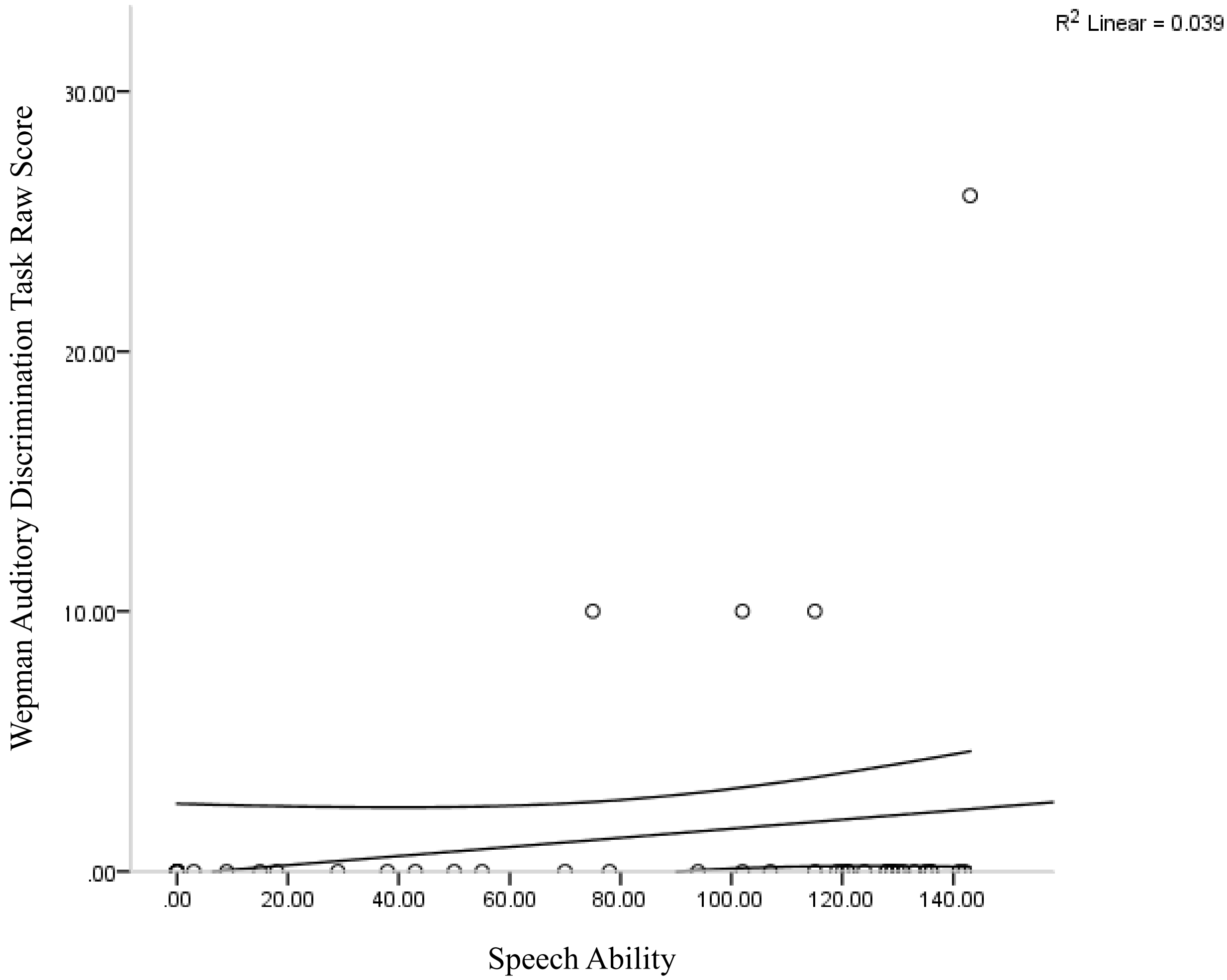

Figure 4. Scatterplot with 95% confidence intervals for speech ability and auditory discrimination. N = 42.

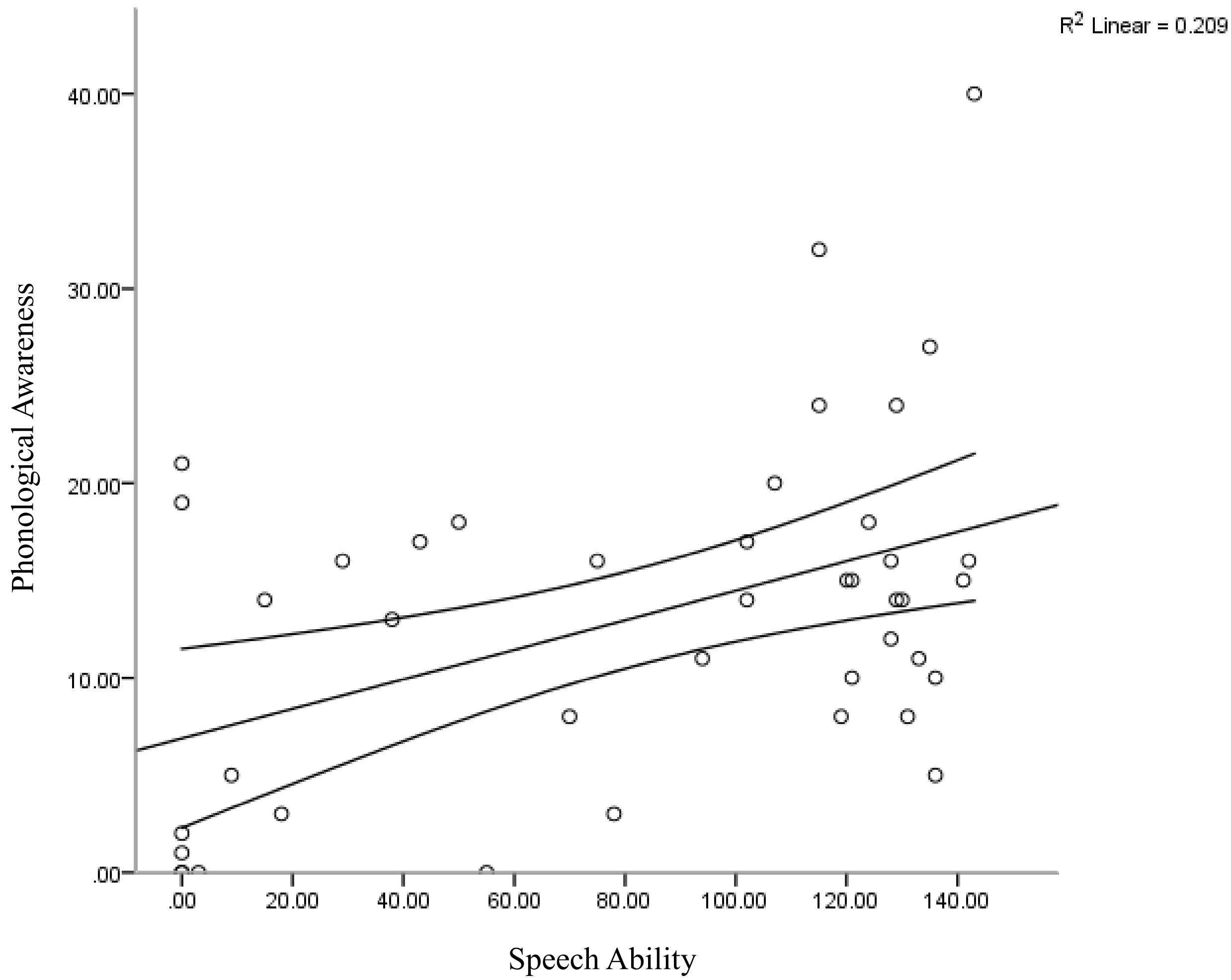

Figure 5. Scatterplot with 95% confidence intervals for speech ability and phonological awareness composite scores.

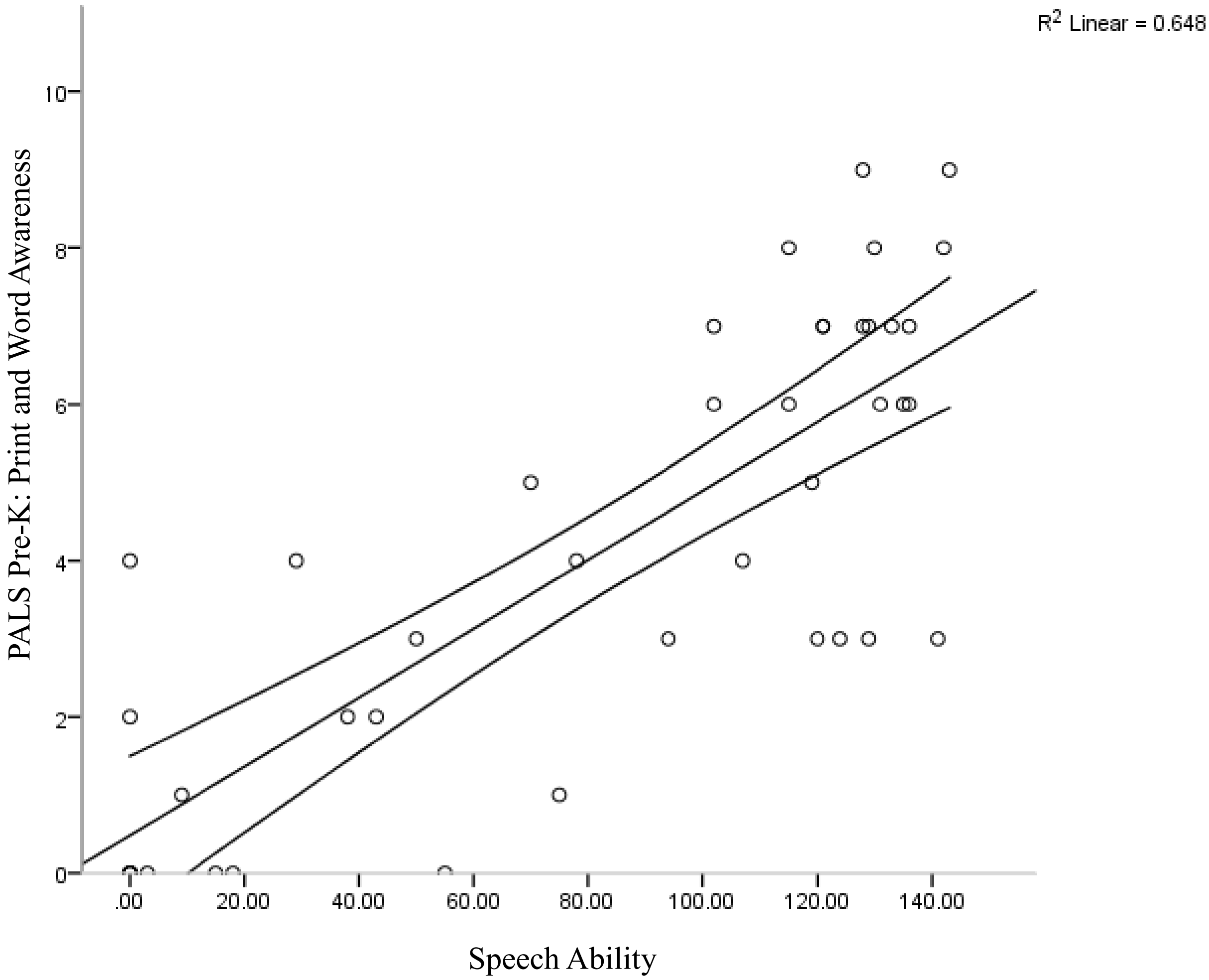

Figure 6. Scatterplot with 95% confidence intervals for speech ability and PALS Pre-K: Print and Word awareness.

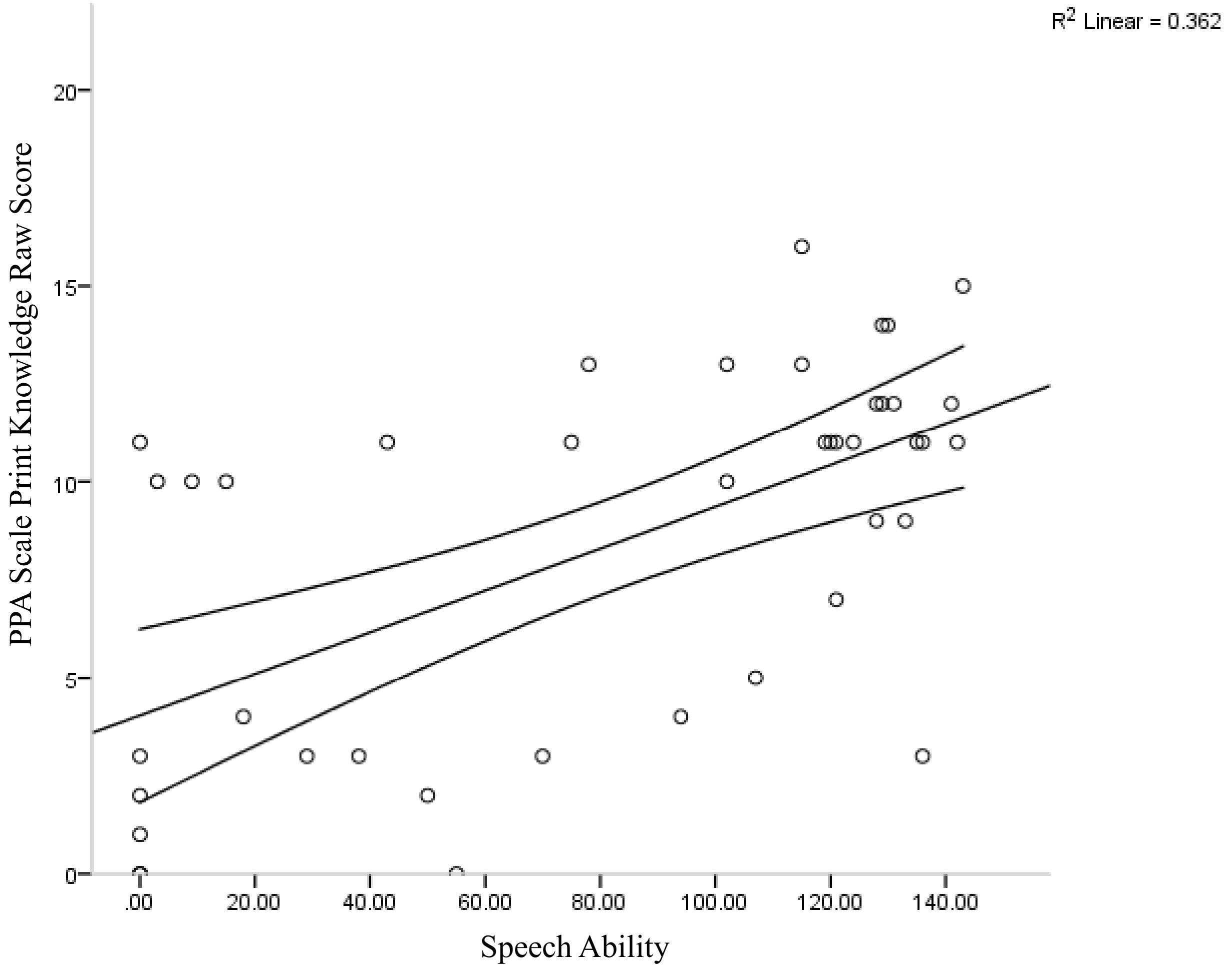

Figure 7. Scatterplot with 95% confidence intervals for speech ability and the Phonological and Print Awareness Scale: Print Knowledge.

4.3 Question 3

What is the relationship between home literacy experience, phonological awareness, orthographic knowledge and speech ability in children with developmental disabilities?

One parent of each child completed surveys of home literacy experiences. Thirty-eight complete surveys were returned from parents out of the 42 participants in the study and were used in data analyses. Surveys provided information about the literacy activities the child and parent regularly engaged in at home as well as information about the parent's reading behavior and perceptions of reading.

Item analysis for the home literacy survey was attempted using principal component analysis (PCA) to determine the number of common components that describe home literacy experiences for children in this study. Thirty-six items related to home literacy were factor analyzed using principal component analysis. Inspection of the correlation matrix showed that many variables had correlations below 0.3 and the overall Kaiser-Meyer-Olkin (KMO) measure was 0.069, a classification of unacceptable according to Kaiser (1974) and is not suitable for factor analysis. Given the large number of items on the survey, relatively small sample size, and uneven distribution of the survey data responses, it was determined that Chronbach's alpha was best suited to measure the reliability of components of home literacy measured in the survey.

Five components of home literacy were identified and assessed for reliability using Chronbach's alpha. Table 7 reports each component, items for that component and component means, standard deviations and alpha. The first component, Shared Literacy, was comprised of items 1 -5, 6-9, 11-13 and 24 – 26. These items collectively evaluated the frequency, context, interest and engagement in book reading by each child. The second component, Technology and Media was comprised of items 14 – 18 and evaluated the frequency and interest of children's use of technology for reading and game play to learn letters and letter sounds. The third component, Response to Print was comprised of items 19 -23 and evaluated the child's understanding and interest in logos, whole words and signs in their environment. The fourth component, Interest in Letters was comprised of items 27 -30 and evaluated the child's understanding and interest in single letters and letter sounds. The fifth and final component, Home print environment and parent perception of reading was comprised of items 31 – 37 and evaluated parent reading behavior, their interest in reading with their child and their perception of the impact of reading with their child on development. Each component was found to have a high level of internal consistency with all alphas above .70.

Table 7 ***Home Literacy Survey Component Means, Standard Deviations and Reliability***

Item	Mean (SD)	α
Shared Literacy	2.04(0.63)	.824
1. Do you or another adult read books to your child?		
2. Does your child ask you to read to him/her?		
3. Does your child independently point to or talk about pictures when you read stories?		
5. Does your child ask questions about characters or events during story reading?		
6. Does your child pretend to read the story in a book?		
7. Do you attempt to teach the names of the letters of the alphabet when reading?		
8. Do you attempt to teach the sounds of the alphabet letters when reading?		
9. In comparison to other activities, how would you rate your child’s interest in books?		
11. How often do you read books that rhyme to your child?		
12. How often do you read books that primarily name objects, colors or animals to your child?		
13. How often do you read books with a simple story or characters to your child?		
24. Do you play rhyming games with your child?		
25. Does your child notice and say something when she/he hears words that rhyme?		
26. Does your child sing simple songs?		
Technology and Media	1.80(0.59)	.822
14. How often do you read books on a tablet/touchscreen device with your child?		
15. How often does your child independently read books on a tablet/touchscreen device?		
16. How often does your child play games involving letters and sounds on a tablet device or computer?		
17. How often does your child play games involving writing and/or typing letters on a tablet device or computer?		
18. How often does your child watch T.V. shows that explicitly focus on letter knowledge, sounds or words?		
Response to Print	1.63(0.81)	.716
19. Do you point out signs and words such as restaurant names or street signs to your child?		
20. Does your child recognize familiar signs and logos such as restaurant names or street signs?		
21. Does your child ask for help in reading words such as signs, words on TV, or words on food pkgs?		
22. Does your child read any words by sight?		

23. Does your child read any words by sounding out the letters?		
Interest in Letters	2.30(0.33)	.802
27. Does your child identify letters of the alphabet?		
28. Does your child attempt to make sounds for alphabet letters?		
29. Does your child identify his/her name in print?		
30. Do you do activities that involve tracing or copying letters or words?		
Home Print Environment and Parent Perception of Reading	2.68(0.90)	.709
31. Not including books required for school courses or your job, how many books do you typically read in one year?		
32. How many magazine subscriptions do you have in your home (mail or e-reader)?		
33. How many books of any kind are in your child's home?		
34. How many children's books are in your child's home?		
35. In comparison to other activities you do with your child, reading is my (0 least - 4 favorite activity)		
36. Reading together helps my child learn to read.		
37. Reading together helps my child learn language.		

Note. N = 38

Figure 8 reports the scatterplot matrices with 95% confidence intervals showing the relationship between children's speech ability, phonological awareness skills and components of the home literacy survey.

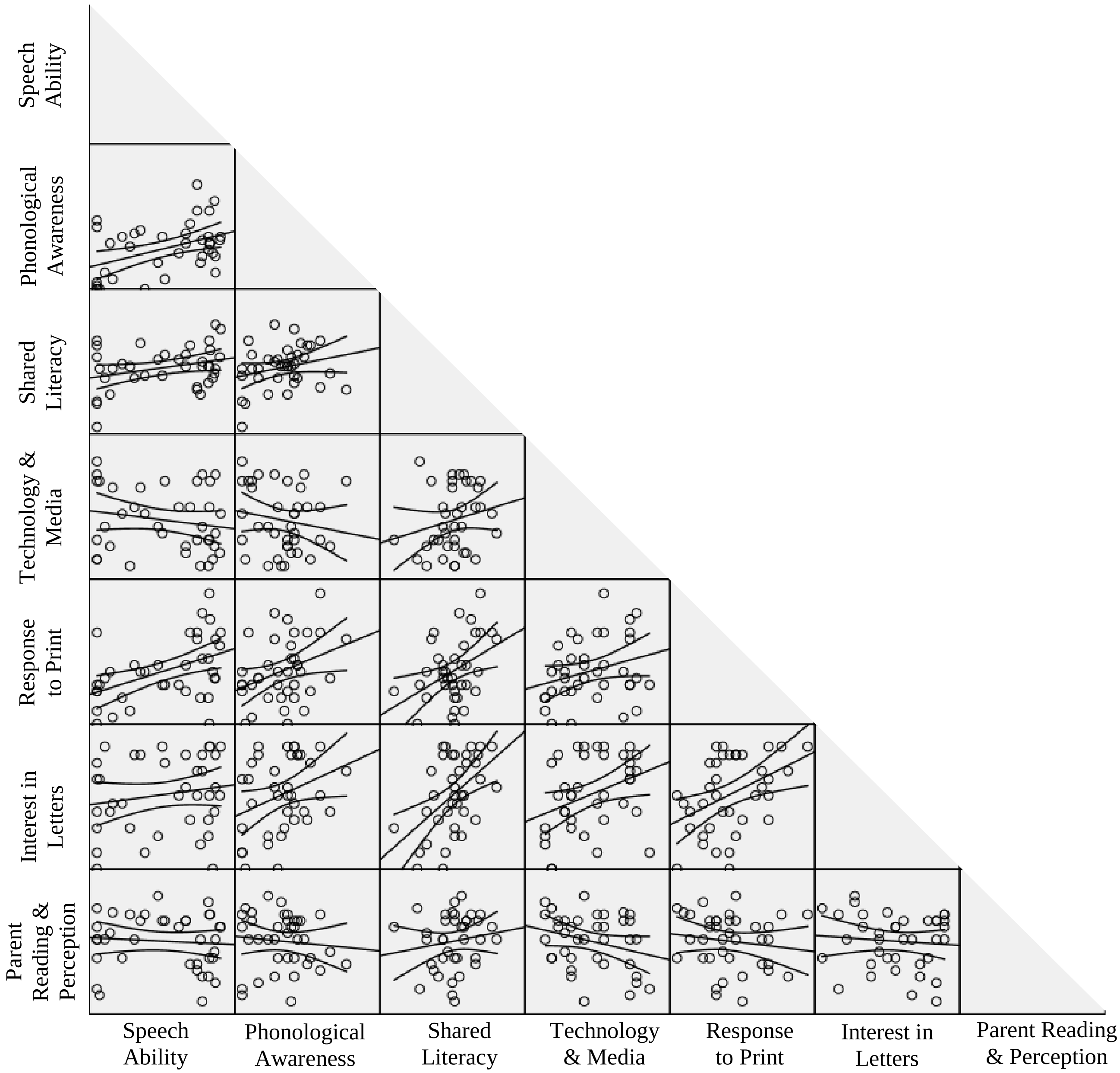

Figure 8. Scatterplot matrices with 95% confidence intervals for speech ability, phonological awareness and home literacy components. N = 38**.**

It is evident by the scatterplots that the relationships between the variables of speech ability and phonological awareness to components of home literacy did not follow a linear pattern. There was a range of home literacy experience for children with the highest speech ability as well as the lowest speech ability.

A Spearman's rank-order correlation was done to assess the relationship between components of home literacy experience, and early reading skills of phonological awareness, orthographic knowledge and speech ability. Table 8 presents the correlation matrix, means, standard deviations and confidence intervals for each. No significant correlations were found between children's speech ability and the overall component of shared literacy ($r_s(38) = .256$, $p = .121$). Speech ability was not correlated with parent's reading or perceptions of reading ($r_s(38) = -.093$, $p = .577$). Speech ability was correlated with children's response to print ($r_s(38) = .458$, $p = .004$). Items on this component of the home literacy survey asked questions that relied heavily on children's speech ability during reading such as "does your child ask for help in reading signs or words on food packages", "does your child read any words by sight?", and "does your child read any words by sounding out the letters?".

Table 8 ***Summary of Spearman's Rank-Order Correlations, Means, Standard Deviations and Confidence Intervals of Home literacy Survey Components, Early Reading skills and Speech ability***

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. PA composite	-									
2. PALS Pre-K	.472**	-								
3. PPA Print Knowledge	.488**	.544**	-							
4. PPA Sound-Symbol	.585**	.507**	.579**	-						
5. Speech ability	.314	.774**	.558**	.354*	-					
6. Shared Literacy	.265	.330*	.055	.245	.256	-				
7. Technology and Media	-.128	-.153	-.074	.001	-.141	.226	-			
8. Response to Print	.312	.475**	.355*	.462**	.458**	.351*	.299	-		
9. Interest in Letters	.342*	.256	.512**	.458**	.207	.459**	.366*	.419*	-	
10. Parent Reading & Perception	-.138	-.102	-.139	-.059	-.093	.207	-.265	-.202	-.065	-
M	12.39	4.00	8.03	3.18	77.53	2.04	1.81	1.63	2.28	2.67
SD	8.03	2.92	4.73	3.07	53.37	0.65	0.97	0.96	1.14	0.63
95% CI	±2.55	±0.93	±1.5	±0.98	±16.97	±0.21	±0.31	±0.3	±0.36	±0.2

Note. N = 38; CI = confidence interval; Speech ability = Kaufman Speech Praxis Test Part 2 and 3 raw composite score (Kaufman, 1995); PALS = Phonological Awareness Literacy Screening-PreK (Invernizzi et al., 2004); PPA = The Phonological and Print Awareness Scale (Williams, 2014); Measures 6, 7, 8, 9 and 10 represent components of the home literacy survey.
* $p < .05$, ** $p < .01$.

The component of shared literacy had a moderate significant correlation with PALS Pre-K print and word awareness scores ($r_s(38) = .330$, $p = .043$), but was not correlated with any other measures of phonological awareness, print knowledge or sound-symbol awareness suggesting that children with greater shared reading experiences are performing better on a measure of general knowledge about the conventions of print, but not specific knowledge such as letter names or letter sounds. Home use of technology and media was not significantly correlated with any measures of early reading ability or speech ability. Parents' report of children's response to print was moderately to highly significantly correlated with all measures of early reading skill except phonological awareness. Children's interest in letters was also moderately to highly significantly correlated with all measures of early reading except for the PALS PreK. There were no significant correlations found between parent reading behavior and perceptions of reading and children's early reading skill or speech ability.

On average, parents began reading to their children at 9.03 months of age (SD = 12.43, range = birth – 48 months). Parents reported that they read to their child at least weekly, with a range from on occasion to several books per day and had between 21 – 40 children's books in their home. All parents agreed that reading together helps their child learn to read. Books were reported to be read on occasion using a tablet or touchscreen device. No parent reported that they never/rarely read to their child. Parents reported that while they read books with their child, only occasionally did they attempt to teach letter names/sounds when reading. Parents reported that their children watched television shows weekly that focused on letter knowledge and played games involving letters and sounds on a tablet device or computer at least weekly. Parents reported that they themselves on average read between 3 – 10 books a year.

4.4 Question 4

What is the relationship between preschool literacy instruction, phonological awareness, orthographic knowledge and speech ability in children with developmental disabilities?

One parent of each child was asked to complete surveys on their perspective of their child's school literacy experiences. Surveys provided information about the type and frequency of literacy instruction their child regularly engaged in during school. Thirty-one out of 42 complete surveys were returned from parents participating in the study and were used in data analyses to describe school literacy instruction. Of the eleven surveys that did not report complete data about his/her child's school literacy experiences, 3 of the 11 surveys were not returned by the child's parent, while the remaining 8 of 11 surveys had answers to some of the survey questions but not all. Seven of the 8 surveys with incomplete answers were from children who had receptive and expressive T scores on the Mullen of 20 or below and had very limited functional use of speech as reported by their parents. The section most frequently left blank by 7 out of the 8 parents was the component of the survey asking about frequency of instruction in decoding and word recognition. This section asked questions about instruction in naming letters, letter sounds and rhyming. One parent left the section asking questions about the frequency of writing instruction blank. Of the 8 incomplete surveys that were returned, 1 child did not have a reported diagnosis, 5 had Autism spectrum disorder, one had Angleman Syndrome and one had Down Syndrome. It should be noted that while there was a range of speech and communication skill for the 31 children whose parents reported complete surveys, 8 of the 11 incomplete surveys were comprised largely of children with limited receptive and expressive communication skills and limited functional speech.

A principal component analysis (PCA) was run on the 16-question school survey that measured the type and frequency of reading instruction provided during school to children as reported by their parents. The suitability of PCA was assessed prior to analysis. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.631. According to Kaiser (1974), this value is ‘mediocre’, but considered acceptable for PCA. Bartlett's Test of Sphericity was statistically significant ($p = .000$), indicating that the data was likely factorizable.

Principal component analysis revealed five components that had eigenvalues greater than one and which explained 35.11%, 15.95%, 13.12%, 8.43% and 6.68% of the total variance, respectively. Visual inspection of the scree plot indicated that three components should be retained (Cattell, 1966). In addition, a three-component solution met the interpretability criterion, therefore three components were retained.

A forced three-factor component solution was done with a Promax Oblique rotation to aid in interpretability. This three factor solution explained 64.18% of the total variance. The rotated solution yielded two items that had multiple component loadings. These items were item 1- *plays rhyming games* and item 11- *defines words during reading instruction.* These two items were removed and a forced three-factor PCA was run again. The final rotated solution explained 66.87% of the total variance. The interpretation of these data without items 1 and 11 was consistent with the components of school literacy instruction the questionnaire was designed to measure with strong loadings for instruction in decoding and word recognition on Component 1, instruction in writing on Component 2, and Use of Technology and AAC for instruction on Component 3. Component loadings, eigenvalues and communalities of the rotated solution are presented in Table 9. Chronbach’s alphas were calculated for each factor to assess the reliability of the survey and are reported in Table 9. Each factor was found to have a high level of internal consistency with alphas above .71.

Table 9 ***Factor Loadings for Principal Component Analysis with Promax Oblique Rotation for School Literacy Survey***

Item	Decoding and Word Recognition	Instruction in Writing	Use of Technology/ Media During Instruction	Communalities
2. Names the letters of the alphabet	**.851**	-.130	-.247	.640
9. Participates in sight word instruction based on commonly occurring words in the community	**.844**	.168	.003	.818
3. Names the sounds of the alphabet letters	**.841**	-.091	-.021	.667
10. Participates in sight word instruction for high frequency words (e.g., *is, of, the, and*)	**.766**	.223	.046	.792
4. Practices sounding out simple words on flashcards	**.695**	.124	.081	.591
13. Traces letters	**.640**	-.136	.303	.562
16. Spells words on an AAC device with voice output	.003	**.944**	-.101	.839
12. Identifies relevant phrases or words using an AAC system during reading instruction	-.153	**.841**	.119	.732
15. Spells words using a keyboard	.196	**.780**	.014	.738
14. Copies simple words	.322	**.409**	-.082	.310
8. Plays games involving letters and sounds on a tablet device or computer during class	-.079	-.095	**.943**	.805
7. Plays games involving writing and/or typing letters on a tablet device or computer	.316	-.175	**.797**	.794
6. Reads books on a tablet/touchscreen and/or smartboard during class	.026	-.087	**.652**	.482
5. Uses an AAC device to sound out letter names or words during reading instruction	-.250	.344	**.637**	.591
Eigenvalues	5.303	2.339	1.719	
% of Variance	37.881	16.708	12.281	
α	.873	.715	.794	

Note. N = 31

Figure 9 reports the scatterplot matrices with 95% confidence intervals showing the relationship between children's speech ability, phonological awareness skills and components of the school literacy survey.

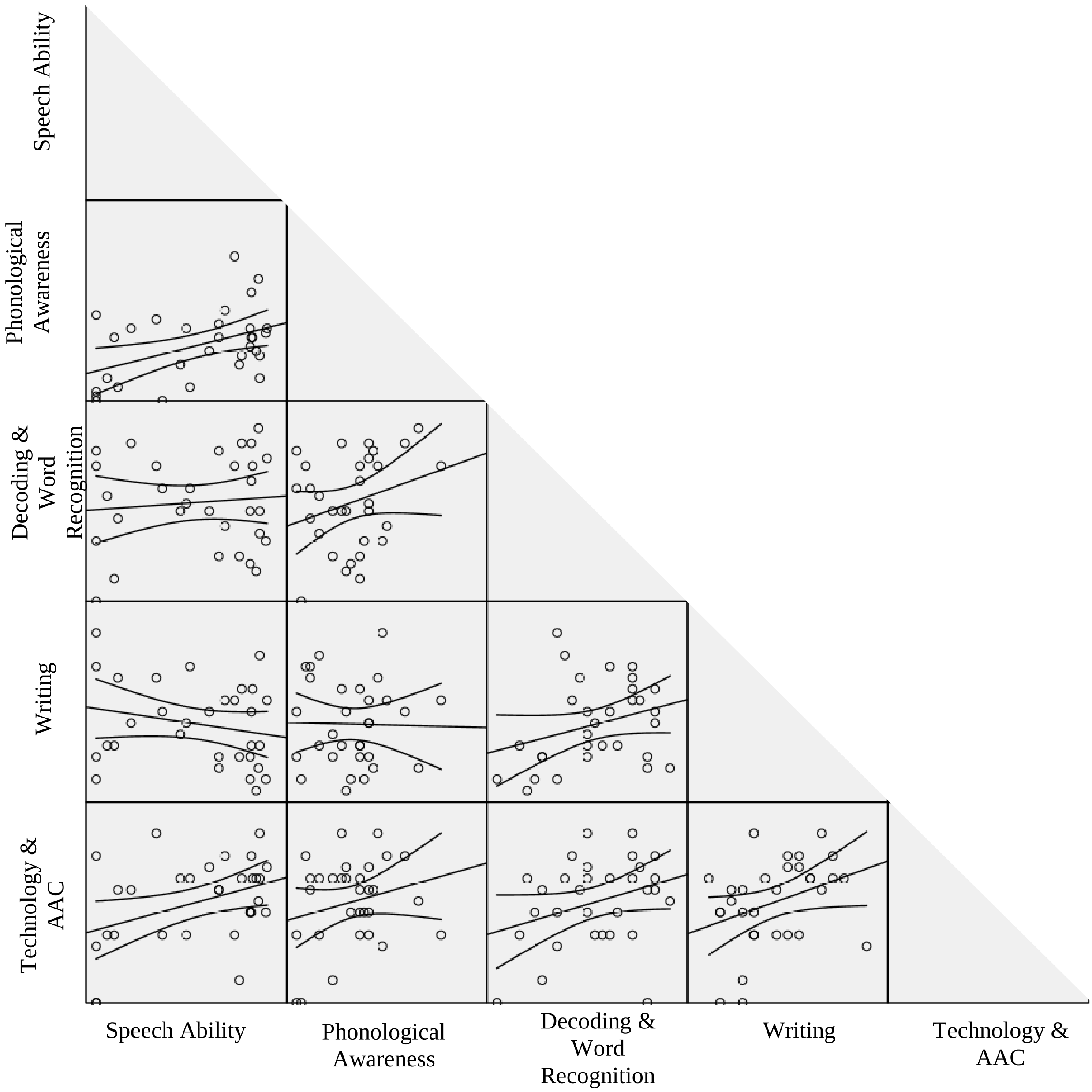

Figure 9. Scatterplot matrices with 95% confidence intervals for speech ability, phonological awareness and school literacy components. N = 31.

It is evident by the scatterplots in Figure 9, that the relationship between speech ability and phonological awareness to measures of school literacy did not follow a linear pattern. There were a range of school literacy experiences for children with the highest speech ability, as well as for children who had the lowest speech ability. There was also a range of instruction provided across children with varying levels of phonological awareness.

A Spearman's rank-order correlation was done to assess the relationship between factors of school literacy experience, early reading skills, and speech ability. Table 10 presents the correlation matrix, means, standard deviations and confidence intervals for each. Overall, parents reported low levels of school literacy instruction. Parents reported that children engaged in components of school literacy instruction from on occasion to weekly. No significant correlations were found between phonological awareness and components of school literacy instruction. Moderate significant correlations were found between the use of technology, media and AAC for instruction and children's speech ability ($r_s(31) = .364$, $p = .044$). Moderate significant correlations were found between the use of technology, media and AAC for instruction and the PALS Pre-K: Print and Word awareness scale ($r_s(31) = .412$, $p = .021$).

Table 10 ***Summary of Spearman's Rank-Order Correlations, Means, Standard Deviations and Confidence Intervals of School literacy Survey Components, Early Reading skills and Speech Ability***

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. PA composite	-							
2. PALS Pre-K	.406*	-						
3. PPA Print Knowledge	.432*	.536**	-					
4. PPA Sound-Symbol	.595*	.616**	.540**	-				
5. KSPT part 2 and 3	.339	.767**	.598**	.494**	-			
6. Decoding and Word Recognition	.258	.175	.192	.278	.070	-		
7. Writing	-.002	-.143	-.070	-.007	-.194	.284	-	
8. Technology and AAC	.155	.412*	.013	.343	.364*	.277	.397*	-
M	12.29	4.16	8.06	2.90	84.71	2.19	1.73	2.23
SD	7.83	2.88	4.80	3.00	51.70	1.03	0.93	0.96
95% CI	±2.76	±1.01	±1.69	±1.06	±18.2	±0.36	±0.33	±0.34

Note. N = 31; CI = confidence interval; KSPT = Kaufman Speech Praxis Test (Kaufman, 1995); PALS = Phonological Awareness Literacy Screening-PreK (Invernizzi et al., 2004); PPA = The Phonological and Print Awareness Scale (Williams, 2014); Measures 6, 7 and 8 represent components of the school literacy survey.

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

4.5 Question 5

What is the relationship between phonological awareness, orthographic knowledge, auditory discrimination and speech ability in children with developmental disabilities?

All variables met the assumptions required for hierarchical regression analysis using the Baron and Kenny (1986) method except for auditory discrimination. Only 4 of 42 participants were able to obtain a raw score on this assessment. Due to floor effects and little variability in this measure, this question was modified to test the amount of variance explained in phonological awareness skill by the predictor variables of orthographic knowledge and speech ability while controlling for age and developmental skill. With an alpha level of 0.05 and sample size of 42, the power to detect a large effect is 0.83. Participant age and developmental skill was entered in step 1, orthographic knowledge was entered in step 2, speech ability was entered in step 3 to determine if speech ability predicted phonological awareness skill beyond what would be expected by age, developmental skill and orthographic knowledge.

Raw scores were used in the regression equation for all variables. A composite raw score for developmental skill was derived by adding raw scores across the Visual Reception, Fine Motor and Receptive Language subtests of the Mullen Scales of Early Learning. Due to the Expressive language subscale being highly correlated (r = .90) with speech ability, the expressive language subtest of the Mullen was not included in the regression equation. A raw score for Orthographic knowledge was derived by combining raw scores for the two subtests of Print Knowledge and Sound Symbol Awareness of the PPA scale. A raw score for speech ability was derived by adding the raw scores from subtests 2 and 3 of the Kaufman Speech Praxis test.

There was independence of residuals as assessed by a Durbin-Watson statistic of 2.333. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. A linear relationship was present between all variables. Figure 10 shows the scatterplot matrices with 95% confidence intervals for the variables of phonological awareness, developmental skill, orthographic knowledge and speech ability used in the regression equation.

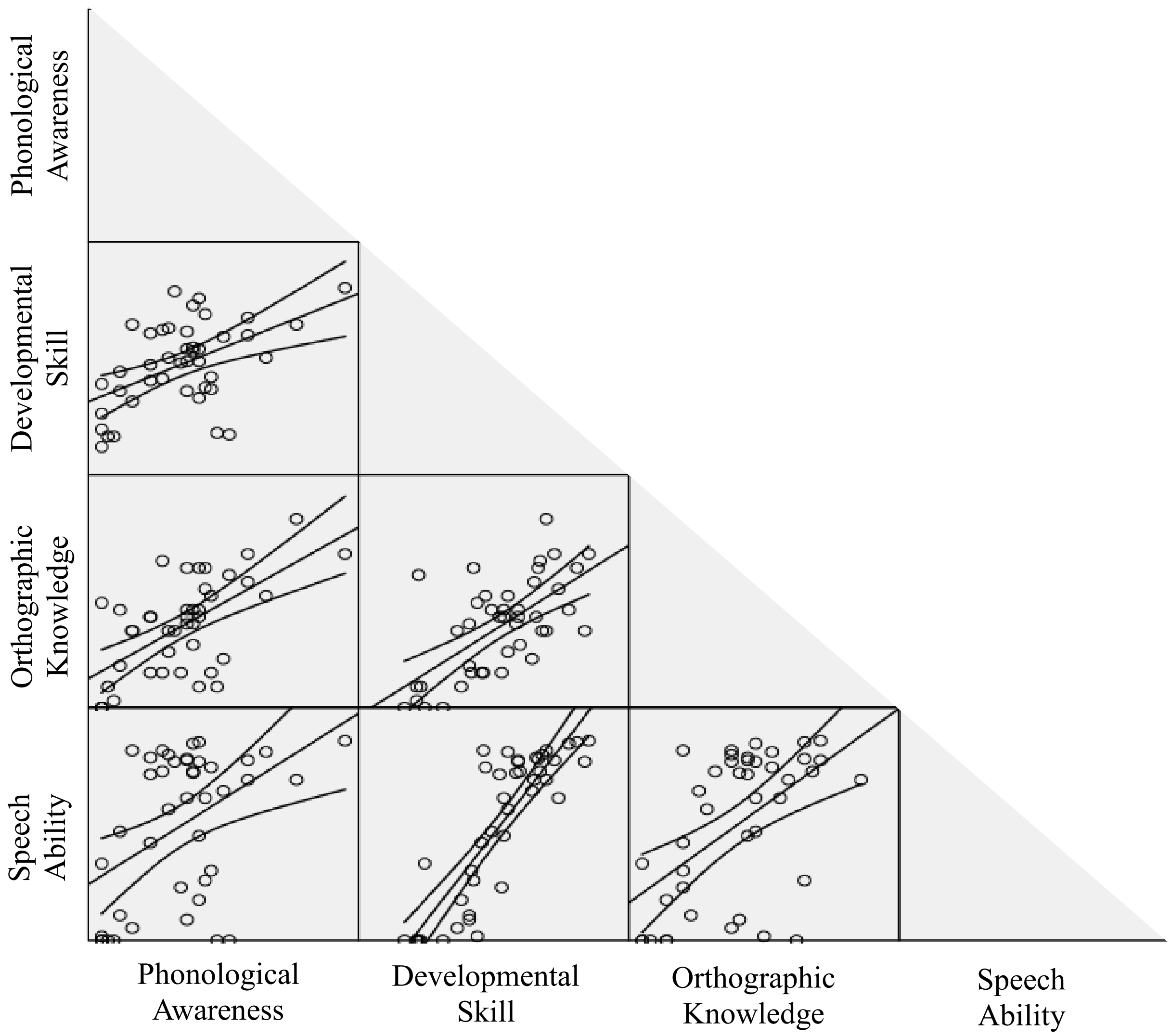

Figure 10. Scatterplot matrices with 95% confidence intervals for the relationship between speech phonological awareness, developmental skill, orthographic knowledge and speech ability. N = 42.

Table 11 reports the bivariate correlations for variables used in the regression equation.

Table 11 ***Pearson Correlations of Measures of Phonological Awareness, Orthographic Knowledge, Speech Ability, and Developmental Skill***

Measure	*1*	*2*	*3*	*4*	*5*
1. PA Composite	-				
2. Age	.275*	-			
3. Developmental Skill	.506**	.391**	-		
4. Orthographic Knowledge	.624**	.164	.645**	-	
5. Speech Ability	.457*	.275*	.856**	.542**	-

Note. N = 42; .PA = Phonological Awareness; Developmental Skill = raw composite score of Visual Reception, Fine Motor and Receptive Language subtests of the Mullen Scales of Early Learning (Mullen, 1995); Speech Ability = Kaufman Speech Praxis Test (Kaufman; 1995) raw score of parts 2 and 3.
*p<.05, **p <.001.

A hierarchical multiple regression was run to determine if the addition of speech ability improved the prediction of phonological awareness beyond what would be expected from children's developmental skill and orthographic knowledge. See Table 12 for full details on each regression model. The full model of age, developmental skill, orthographic knowledge and speech ability to predict phonological awareness (Model 3) was statistically significant, R^2 = .431, F(4, 37) = 7.005, p = .000; adjusted R^2 = .369. The addition of age and developmental skill to the prediction of phonological awareness (Model 1) led to a statistically significant ΔR^2 of .263, F(2, 39) = 6.946, p = .003. The addition of orthographic knowledge to the prediction of phonological awareness (Model 2) also led to a statistically significant ΔR^2 of .163, F(3, 38) = 9.377, p = .002. In the final model however, the addition of speech ability to the prediction of phonological awareness (Model 3) did not lead to a statistically significant ΔR^2 of .006, F(4, 37) = 7.005, p = 0.552.

Table 12 ***Hierarchical Multiple Regression Predicting Phonological Awareness from Age, Developmental skill, Orthographic Knowledge and Speech Ability***

	Model 1			Model 2			Model 3		
Variable	B	SE	β	B	SE	β	B	SE	β
Constant	-11.609	10.919		-10.223	9.774		-8.194	10.419	
Age	.126	.207	.091	.202	.187	.146	.217	.190	.157
Developmental Skill	.171**	.054	.470	.038	.063	.106	-.009	.102	-.026
Orthographic knowledge				.680**	.207	.532	.685**	.209	.536
Speech Ability							.024	.040	.145
R^2	0.263			0.425			0.431		
F	6.946**			9.377**			7.005**		
ΔR^2	0.263			0.163			0.006		
ΔF	6.946**			10.762**			0.361		

Note. Developmental Skill = raw composite score of Visual Reception, Fine Motor and Receptive Language subtests of the Mullen Scales of Early Learning (Mullen, 1995); Speech Ability = Kaufman Speech Praxis Test (Kaufman; 1995) raw score of parts 2 and 3. *p<.05, **p <.001.

Overall, a range of skill in all areas of direct assessment of speech ability, developmental skills, early reading skills, language and vocabulary were found. Children with limited speech were found to have emerging skills in letter knowledge, letter-sound knowledge and phonological awareness. Children in this study had home literacy experiences that included shared reading experiences, access to technology for reading and game play, and positive parent perceptions about reading with their child. No significant correlation between children's speech ability and shared literacy experiences at home were found. Parents reported low levels of reading instruction at school, with no significant correlations found between school literacy instruction and phonological awareness skill of the children. Speech ability did not explain a significant amount of variance in phonological awareness beyond what would be expected by age, development skill, receptive language and orthographic knowledge. Results suggest that for this sample of children between 4 - 5 years of age, speech ability is not predictive of phonological awareness skill.

5 DISCUSSION

This study contributes to our understanding of the relationship between key intrinsic and extrinsic factors that are related to the development of phonological awareness in children with developmental disabilities. Results provide important implications for practitioners and researchers alike in understanding the factors at play in the development of foundational reading skills of phonological awareness in children with developmental disabilities during preschool. Of particular interest in this study is the contribution of speech ability to early reading skills. Prior research has not systematically evaluated the relationship between speech ability and early reading skills in children between the ages of 4 and 5 with developmental disabilities as was done in this study. Findings from this study support the work of Card and Dodd (2006) and Vandervelden and Siegel (1999) that were done with school age children with cerebral palsy suggesting that speech ability does not play a significant role in phonological awareness skill when controlling for cognitive skills inclusive of receptive language. Children's letter knowledge and letter-sound knowledge were instead found to be the most significant predictors of phonological awareness. An understanding of the home literacy environment and school literacy instruction provided to children in this study yielded a context in which to evaluate the contribution his/her learning environment may have had on early reading skills. Furthermore, a current understanding of the strengths and weaknesses in literacy instruction provided to children with developmental disabilities at early stages of reading development in school can inform clinicians, teachers and researchers alike.

The first and second questions in this study address the relationship between intrinsic factors of early reading, speech and language that were directly assessed with each child. These intrinsic components were speech ability, developmental skill (inclusive of receptive and expressive language), receptive vocabulary, phonological awareness, orthographic knowledge, and auditory discrimination in children with developmental disabilities. Hypotheses were partially supported in that there was a greater amount of low performance than average performance across most measures of direct assessment, however children were found to have a range of ability across all areas directly assessed, with strong, positive correlations found between many of the variables. The Wepman auditory discrimination task however had small, nonsignificant relationships between a number of variables including speech ability. Speech ability and letter-sound knowledge were also found to have a small, nonsignificant correlation.

Given the children's difficulty understanding the directions for the auditory discrimination task, correlations with auditory discrimination should be interpreted with caution. Future work should explore alternate modes of assessing auditory discrimination that do not require children to comprehend the concept of same vs different to produce an answer. One method, recently examined by White-Schwoch and colleagues (2015) used neurophysiological markers, i.e., auditory brainstem response to complex sounds cABR, to measure the ability of preschoolers as young as 3 to discriminate consonant-vowel sounds from background noise. This ability is suggested to strongly predict phonological processing in preschoolers above what would be expected by language ability. Passive methods that remove the demands of language processing for instruction for children with developmental disabilities could provide a more pure measure of auditory discrimination to explain the factors at play in early reading development for these children. The inherent difficulty in using these methods however, is the invasive use of technology physically placed on the child to determine a neurological response. Other passive methods using preferential looking paradigms may also be effective and should be considered to assess auditory discrimination in children with developmental disabilities and language impairment.

Additionally, the nonsignificant relationship between sound-symbol awareness and speech ability should be interpreted with caution. There was not a range of performance on the sound-symbol awareness task as there was on tasks of other early reading measures. While there were some children who had high sound-symbol awareness regardless of speech ability, the majority of children, regardless of speech ability performed in the low range of performance. It should be noted that this task again, had inherent language processing demands that may have limited the performance of children on this measure. Children were asked to find either the letter that made the first sound in a word, or the letter that made the last sound in a word. Three practice templates were provided by the examiner before each sub-section (first or last sound). Some children learned very quickly what was being asked of them and others had difficulty understanding the directions of the task. Perhaps children who learned the task more quickly had greater skill in letter-sound knowledge, however future research should explore assessment tools that reduce the language demands of the task. There are no other published assessment tools currently available to assess sound-symbol awareness such as this one that do not require a spoken response. Future research should refine and test methods of assessing sound symbol awareness that do not require a spoken response.

While speech, phonological awareness, developmental skill and language were all positively and significantly correlated, examining the scatterplots of children's performance on these measures is helpful in interpreting differences noticed in the pattern of linear relationships between these variables and further describing the children in this study. A main question of interest, the relationship between speech ability and phonological awareness is depicted in Figure 5. This scatterplot shows that the linear relationship was not perfect. Children with the lowest speech ability evidenced a range of phonological awareness skills, many with raw scores above 10, while children with the greatest speech ability also evidenced a range of phonological awareness skills. Figure 6 depicts a stronger linear relationship between speech ability and knowledge about the conventions of a book, while Figure 7 illustrates the relationship between speech ability and print knowledge is not as strong. Children with low speech ability again are shown to have a range of skills in print knowledge as well as children with high speech ability.

The third question in this study addressed the relationship between speech ability, home literacy experience, phonological awareness and orthographic knowledge in children with developmental disabilities. It was hypothesized that strong, positive correlations would be found between home literacy experiences, orthographic knowledge, phonological awareness and speech ability. This hypothesis was partially supported. A medium positive correlation was found between shared literacy experiences and children's broad understanding of the conventions of print; however shared reading experience was not a significant correlate to phonological awareness, specific print knowledge, sound-symbol awareness or speech ability.

Of particular interest is the nonsignificant relationship found between speech ability and shared reading experiences. Prior literature suggests that children with speech and language impairments have less engagement with their parents in reading, along with low expectations from their parents (Boudreau, 2005; Koppenhaver et al., 1995). Results from this study suggest that parents of young children with developmental disabilities are reading to their children at least weekly and have positive perceptions of the role reading to their children will play in reading development. When looking specifically at speech ability in this group of children with developmental disabilities, speech production skill was not a significant correlate to the amount of shared reading time parents and children spent together, the frequency of books read at home, or children's interest in books. Findings from this study suggest that parents are supporting their children's reading development by frequently engaging in shared reading experiences regardless of his/her child's speech ability.

The finding that speech ability was only correlated with the home literacy component of Response to Print is expected. The items evaluated in this section of the home questionnaire were related to children's expressive speech response when seeing words (e.g., does your child read sight words?, sound out words?, ask for help in reading?). Twenty-five of the 42 children in this study had limited speech (spoke in short phrases, used single words, or no words at all), however only 2 children were reported to use an SGD daily. The majority of children with limited speech (n = 25) in this study did not have access to a modality of expression during shared reading experiences with their parents, resulting in low scores ranging from ‘on occasion’ to ‘never/rarely’ for portions of the home survey that asked about their child’s productive response during shared reading.

Nonsignificant findings for the relationship between phonological awareness and shared reading experiences are consistent with prior work of Levy et al. (2006) and Foy and Mann (2006) who found that for typically developing children 48 to 83 months of age, the extent of home literacy activities did not predict phonological awareness. Letter knowledge however, was a significant correlate in each study. The current study did not find significant correlates between shared literacy experience and letter knowledge, but it did find significant correlates between shared literacy experience and children’s understanding of conventions of print. Given that children in this study had developmental disabilities and lower overall letter knowledge than their same age typically developing peers, it seems appropriate that there is at least a relationship between children’s understanding of the conventions of a book (e.g., the difference between letters and pictures, where the title of the book is, where to start reading, and directionality of print) and shared literacy experience. Perhaps with more time to develop letter knowledge, this same relationship between shared reading experiences and letter knowledge would emerge for children with developmental disabilities.

For children in this study, it does not appear that parent reading behavior and perceptions of reading were a significant correlate to child reading outcomes. Given the limited range of child reading outcomes and relatively frequent and positive perceptions of reading for parents in this study, this relationship is expected.

The use of technology and media for reading related activities was not correlated with children's early reading skills or speech ability. This finding is somewhat surprising given the anecdotal information from parents and teachers throughout the study reporting the use of technology at home. It is consistent however with findings from Foy and Mann (2003) for typically developing children that suggests that even when children had access to technology to play games that teach letters and letter-sounds, they did not seem to benefit from that instruction until close to 6 years of age. Parents reported that children used technology (e.g., tablet or touchscreen devices) on occasion to weekly at home for reading or reading activities. The seemingly wide use of reading applications (apps) on tablet technology for learning letters and letter-sounds was not reflected in the response of parents in this study. Perhaps children in this study need a greater amount of support to navigate apps that teach reading skills; therefore parents are less likely to introduce them to their children. Or, perhaps parents in this study had limited access to tablet technology to use with their child. Future studies should examine the reason parents may or may not provide access to technology for their children with developmental disabilities, especially for children with limited speech ability.

The fourth question in this study addressed the relationship between school literacy instruction, phonological awareness, orthographic knowledge and speech ability in children with developmental disabilities. It was hypothesized that strong, positive correlations would be found between preschool literacy instruction, orthographic knowledge, phonological awareness and speech ability. This hypothesis was partially supported. Teachers were reported to engage in activities of decoding and word recognition at least weekly. They also were reported to use technology and/or AAC at least weekly for instruction. Teachers were reported to occasionally provide instruction in writing.

Significant correlations were found between the use of technology, media and AAC for instruction and speech ability. With recent advances in technology within the classroom, it is important to note that technology is being implemented for instruction with children with developmental disabilities. Findings from this study suggest that these supports for instruction are at least being used on occasion with variability across classrooms and children that range up to daily use of technology. Given that half of the children in this study had limited speech, it is encouraging to know that technology and AAC supports are being accessed by teachers, however future research should examine the type of instruction and need for teacher scaffolding of information alongside the technology. The only positive and significant reading related outcome to the use of technology was children's understanding of the conventions of print. Similar to the findings from the home survey, phonological awareness, letter knowledge or letter-sound knowledge were not correlated with the use of technology in the classroom for instruction.

Overall, for children in this sample with developmental disabilities, children's speech ability was not related to the frequency of instruction provided in decoding and word recognition or writing. Nonsignificant, small correlations were found between speech ability and classroom instruction in decoding and word recognition and writing. It does not appear that in this sample, children's speech ability played an important role in the delivery of reading instruction in the classroom. It was hypothesized that children with limited speech ability would have less access to reading instruction, but results from this study suggest that overall, children with developmental disabilities regardless of speech ability have limited access to reading instruction. For example, a frequent activity for typically developing children in preschool is to play rhyming games to facilitate comprehension of phonological patterns in words. Overall, parents reported that children played rhyming games on occasion.

It is important to note that results from the school survey should be interpreted with caution given that parents reported their perspective of their child's classroom reading instruction and not teachers. Parents frequently left sections of the school survey blank, leaving only 31 surveys available for data analyses. Future work should examine the parent response to school surveys in greater detail, evaluating the items that may have been systematically omitted. Future work also should directly ask teachers about the classroom reading instruction being provided in preschool. Work to date largely is concerned with teacher perspectives on reading instruction for students in special education (Ruppar, Dymond, & Gaffney, 2011). Surveys that directly assess the frequency, content and modality of reading instruction in the classroom such as the one used in this study could provide greater detail regarding the services provided to children with developmental disabilities and the impact those services may have on their early reading development.

The fifth and final question addressed a central focus of this study; to determine what intrinsic factors best predict phonological awareness skill in preschool age children with developmental disabilities. It was hypothesized that speech ability would be a significant predictor of phonological awareness, however in the final regression model, it was not speech ability, but orthographic knowledge that remained a significant predictor of phonological awareness skill, even beyond what would be expected by developmental skill alone. Children in this study had a range of developmental skills and receptive language ability. This study suggests that letter knowledge and developmental skill are related, but children may have a range of print knowledge and letter-sound knowledge regardless of their developmental ability. While vocabulary knowledge was not part of the equation, vocabulary knowledge had an even higher correlation with phonological awareness than orthographic knowledge, beyond that of cognitive and receptive language skills assessed by the Mullen. Children in this study with developmental disabilities who have strengths in orthographic knowledge and vocabulary may have greater overall linguistic knowledge that they were able to use for phonological awareness tasks. This interpretation of the results of this study supports the findings of Perfetti (1985) and Perfetti et al. (1981) suggesting the reciprocal relationships between knowledge of print, vocabulary and phonological awareness. The results of this study suggest that the ability to speak is not an important component in the development of linguistic knowledge necessary for phonological awareness. Findings from this study support the work of Card and Dodd (2006) and Vandervelden and Siegel (1999) suggesting that speech ability does not play a significant role in phonological awareness skill when controlling for cognitive skills inclusive of receptive language. Future directions should explore the use of SGDs to adapt phonological awareness instruction in preschool so that children with limited speech may have access reading instruction. Given the links found between letter and letter-sound knowledge, children with limited speech may benefit from reading instruction using letters and words that may provide an alternate mode of expression during instruction and in turn support the development of phonological awareness.

5.1 Limitations

5.1.1 Measurement.

A number of limitations of this study have been addressed throughout the discussion regarding specific measures described. Measures of phonological awareness, letter knowledge, letter-sound knowledge and speech ability produced both floor and ceiling effects for children in this study. The measurement tools used to assess children in this study may be less sensitive in measuring particularly the low skill level of many children who participated. For example, many children had very low raw scores on the test of sound-symbol awareness. This assessment used only a limited number of letters and sounds and assessed knowledge of sounds using linguistically complex instructions. Children in this study often had difficulty understanding the task. However, when children were asked to imitate consonant speech sounds on the KSPT, children often said the letter name of the sound that was made by the examiner (e.g., child said “C” when asked to imitate the /k/ sound), but could not perform the task of sound-symbol matching when directly assessed using the PPA. The Wepman ADT was also difficult to use with children in this study due to limitations in receptive language. In order to validly assess early component reading skills of children with significant disabilities with limitations in receptive and expressive language, assessment tools that are sensitive to measuring the true abilities of children are needed. The assessment tools used in this study to assess reading and speech ability were not designed to be used with children with significant developmental disabilities and receptive language delays. Further research is warranted exploring the measurement properties of these tools and how they function with children with IDD and receptive and expressive language delays.

5.1.2 Phonological awareness assessment.

An additional and important limitation is in the method of assessment of phonological awareness used in this study. This study assessed phonological awareness using an experimental task developed by Preston and Edwards (2010) to measure phonological awareness without requiring a spoken response. Similar patterns of performance were found by children in this study as were found in Preston and Edwards (2010), with greater scores on subtests of rhyme awareness and lower scores on final subtests assessing blending phonemes. It should be noted however, that vocabulary knowledge may play an important role in children’s response to this assessment task. Because the assessment did not require a spoken response, it relied on children to pick from one of 4 pictures presented on a computer touchscreen. Children were provided the name of each picture prior to answering; however there were inherent demands of language processing and vocabulary knowledge during the task, specifically for the final items of blending. In the final subtest, children were presented with three choices that differed minimally by phonemes (e.g., mouse, house, mouth). Children then heard three phonemes (e.g. /m/ /ou/ /s/ = mouse) separately and were asked to choose the picture that was said. Vocabulary skill is inherently part of this task to choose the correct referent. Barker, Saunders and Brady (2012) suggest that future research should refine ways to assess phonological awareness using tasks that are less dependent on vocabulary knowledge. The relationship between phonological awareness and vocabulary however, seems tightly woven, especially for tasks involving blending. Furthermore, Perfetti (1985) and Liberman, Shankweiler and Liberman (1989) suggest that the semantic content of words provides linguistic support in breaking apart the smaller sound units of a word. It may be necessary to assess phonological awareness with vocabulary that children at least understand to ensure the construct that is being assessed is related to later reading development.

This study provides a description of the relationship between a number of intrinsic and extrinsic factors related to phonological awareness skill in preschool age children with developmental disabilities. Future work should continue to refine our understanding of the relationships between these variables using assessment tools that allow inclusion of children with limited speech ability and may use AAC systems as a primary means of communication. An assessment tool central to the findings in this study was an experimental tool to measure phonological awareness that did not require a spoken response. There is a great need for the validity and development of such assessment tools that can be used with preschool age children with limited speech ability. The development of assessment tools that do not require speech production are a necessary first step that will allow for measurement of reading intervention outcomes for students with limited speech ability. These assessment tools allow us to understand component reading skills of children with limited speech. With a greater understanding of the component factors involved in the development of early reading skills, we can create strategies to instruct children with a range of speech ability in these fundamental reading skills. Future strategies should examine ways to incorporate AAC systems into reading instruction with children who have limited speech ability. With greater reading skills, children with developmental disabilities and limited speech may have greater access to AAC supports and the academic curriculum to promote growth and development to their fullest potential.

REFERENCES

Allor, J. H., Mathes, P. G., Roberts, J. K., Cheatham, J. P., & Champlin, T. M. (2010). Comprehensive reading instruction for students with intellectual disabilities: Findings from the first three years. *Psychology in the Schools*, *47*(5), 445 – 466. doi:10.1002/pits

Anthony, J. L., Aghara, R. G., Dunkelberger, M. J., Anthony, T. I., Williams, J. M., & Zhang, Z. (2011). What factors place children with speech sound disorders at risk for reading problems? *American Journal of Speech-Language Pathology*, *20*(May), 146–160. doi:10.1044/1058-0360(2011/10-0053)

Baker, J. N., Spooner, F., Ahlgrim-Delzell, L., Flowers, C., & Browder, D. M. (2010). A measure of emergent literacy for students with severe developmental disabilities. *Psychology in the Schools*, *47*(5), 501-513.

Barker, R. M., Saunders, K. J., & Brady, N. C. (2012). Reading instruction for children who use AAC: considerations in the pursuit of generalizable results. *Augmentative and Alternative Communication* *28*(3), 160–170. doi:10.3109/07434618.2012.704523

Barker, R. M., Sevcik, R. A., Morris, R. D., & Romski, M. (2013). A model of phonological processing, language, and reading for students with mild intellectual disability. *American Journal on Intellectual and Developmental Disabilities*, *118*(5), 365-380.

Barker, R. M., Bridges, M. S., & Saunders, K. J. (2014). Validity of a non-speech dynamic assessment of phonemic awareness via the alphabetic principle. *Augmentative and Alternative Communication 30*(1), 71–82. doi:10.3109/07434618.2014.880190

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology, 51*(6), 1173.

Beukelman, D. R., & Mirenda, P. (2013). *Supporting children and adults with complex communication needs, fourth edition.* Baltimore, MD: Brookes Publishing.

Bishop, D. V. M., & Robson, J. (1989). Unimpaired short-term memory and rhyme judgement in congenitally speechless individuals: Implications for the notion of "articulatory coding". *The Quarterly Journal of Experimental Psychology*, *41*(1), 123-140.

Boets, B., Ghesquière, P., van Wieringen, A., & Wouters, J. (2007). Speech perception in preschoolers at family risk for dyslexia: Relations with low-level auditory processing and phonological ability. *Brain and Language*, *101*, 19–30. doi:10.1016/j.bandl.2006.06.009

Boudreau, D. (2005). Use of a parent questionnaire in emergent and early literacy assessment of preschool children. *Language, Speech, and Hearing Services in Schools*, *36*(1), 33-47.

Boyle, C. A, Boulet, S., Schieve, L. A, Cohen, R. A, Blumberg, S. J., Yeargin-Allsopp, M., … Kogan, M. D. (2011). Trends in the prevalence of developmental disabilities in US children, 1997-2008. *Pediatrics*, *127*, 1034–1042. doi:10.1542/peds.2010-2989

Bradford, S., Shippen, M. E., Alberto, P., Houchins, D. E., & Flores, M. (2006). Using Systematic Instruction to Teach Decoding Skills to Middle School Students with Moderate Intellectual Disabilities, *41*(4), 333–343.

Bradley, L., & Bryant, P. (1991). Phonological skills before and after learning to read. In Brady, S.A., Shankweiler, D. P. (Eds.) *Phonological Processes in Literacy: A tribute to Isabelle Y. Liberman* (pp. 37-45). Routledge

Brady, S., Shankweiler, D., & Mann, V. (1983). Speech perception and memory coding in relation to reading ability. *Journal of Experimental Child Psychology*, *35*(2), 345-367.

Browder, D. M., Ahlgrim-Delzell, L., Courtade, G., Gibbs, S. L., & Flowers, C. (2008). Evaluation of the effectiveness of an early literacy program for students with significant developmental disabilities. *Exceptional Children*, *75*(1), 33–52.

Card, R., & Dodd, B. (2006). The phonological awareness abilities of children with cerebral palsy who do not speak. *Augmentative and Alternative Communication*, *22*, 149–159. doi:10.1080/07434610500431694

Connor, C.M., Alberto, P.A., Compton, D.L., O'Connor, R.E. (2014). Improving Reading Outcomes for Students with or at Risk for Reading Disabilities: A Synthesis of the Contributions from the Institute of Education Sciences Research Centers (NCSER 2014 3000). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/

Conners, F. A, Atwell, J. A, Rosenquist, C. J., & Sligh, A. C. (2001). Abilities underlying decoding differences in children with intellectual disability. *Journal of Intellectual Disability Research*, *45*(4), 292–9. Retrieved from http://www.ncbi.nlm.nih.gov/ pubmed/11489050

Conners, F. A., Rosenquist, C. J., Sligh, A. C., Atwell, J. A., & Kiser, T. (2006). Phonological reading skills acquisition by children with mental retardation. *Research in developmental disabilities*, *27*(2), 121-137.

Cupples, L., & Iacono, T. (2000). Phonological awareness and oral reading skill in children with Down Syndrome. *Journal of Speech, Language and Hearing Research*, *43*, 595 – 608.

Dahlgren Sandberg, A. (2001). Reading and spelling, phonological awareness, and working memory in children with severe speech impairments: A longitudinal study. *Augmentative and Alternative Communication*, *17*(1), 11-26.

Dunn & Dunn (2007). *Peabody Picture Vocabulary Test, 4th Edition.* Pearson Assessments.

Dynia, J. M., Lawton, K., Logan, J. A. R., & Justice, L. M. (2014). Comparing emergent-literacy skills and home-literacy environment of children with autism and their peers. *Topics in Early Childhood Special Education*, 1–12. doi:10.1177/0271121414536784.

Ehri, L. (2004). Teaching phonemic awareness and phonics. In McArdle, P. E., & Chhabra, V. E. (Eds), *The Voice of Evidence in Reading Research* (pp. 153-186). Baltimore, MD: Paul H Brookes Publishing.

Erickson, K. A., & Koppenhaver, D. A. (1995). Developing a literacy program for children with severe disabilities. *The Reading Teacher*, 676-684.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149–60. doi:10.3758/BRM.41.4.1149

Foley, B. & Pollatsek, A. (1999). Phonological processing and reading abilities in adolescents and adults with severe congenital speech impairments. *Augmentative and Alternative Communication, 15,* 156 – 173.

Foy, J. G., & Mann, V. (2003). Home literacy environment and phonological awareness in preschool children: Differential effects for rhyme and phoneme awareness. *Applied Psycholinguistics, 24,* 59–88. doi:10.1017/S0142716403000043

Frost, S. J., Landi, N., Mencl, W. E., Sandak, R., Fulbright, R. K., Tejada, E. T., ... & Pugh, K. R. (2009). Phonological awareness predicts activation patterns for print and speech. *Annals of Dyslexia*, *59*(1), 78-97.

Gillam, S. L., Fargo, J., Foley, B., & Olszewski, A. (2011). A nonverbal phoneme deletion task administered in a dynamic assessment format. *Journal of Communication Disorders*, *44*(2), 236–45. doi:10.1016/j.jcomdis.2010.11.003

Gillon, G. T. (2005). Facilitating phoneme awareness development in 3- and 4-year-old children with speech impairment. *Language, Speech, and Hearing Services in Schools, 36*, 308 324. doi:10.1044/0161-1461(2005/031)

Hedrick, W. B., Katims, D. S., & Carr, N. J. (1999). Implementing a multimethod, multilevel literacy program for students with mental retardation. *Focus on Autism and Other Developmental Disabilities*, *14*, 231 – 239.

Iacono, T. A., & Cupples, L. (2004). Assessment of phonemic awareness and word reading skills of people with complex communication needs. *Journal of Speech, Language, and Hearing Research, 47*, 437-449. doi: 10.1044/1092-4388(2004/035)

Invernizzi, Sullivan, Meier, & Swank, (2004). *Phonological Awareness Literacy Screening-PreK*. University of Virginia.

Johnston, S. S., Davenport, L., Kanarowski, B., Rhodehouse, S., & McDonnell, A. P. (2009). Teaching sound letter correspondence and consonant-vowel-consonant combinations to young children who use augmentative and alternative communication. *Augmentative and Alternative Communication*, *25*(2), 123–35. doi:10.1080/07434610902921409

Justice, L. M., Mashburn, A., Hamre, B., & Pianta, R. (2008). Quality of language and literacy instruction in preschool classrooms serving at-risk pupils. *Early Child Res Q*, *23*(1), 51 68. doi:10.1016/j.ecresq.2007.09.004

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39*(1), 31-36.

Kaufman, N. R. (1995). *Kaufman Speech Praxis Test for Children.* Wayne State University Press.

Koppenhaver, D. A., Pierce, P., Steelman, J. D., & Yoder, D. E. (1995). Contexts of early literacy intervention for children with developmental disabilities. *Language Intervention: Preschool Through the Elementary Years*, *5*, 241-274.

Leitão, S., & Fletcher, J. (2004). Literacy outcomes for students with speech impairment: long term follow-up. *International Journal of Language & Communication Disorders / Royal College of Speech & Language Therapists*, *39*, 245–256. doi:10.1080/136828203100016 19478

Levy, B. A., Gong, Z., Hessels, S., Evans, M. A., & Jared, D. (2006). Understanding print: Early reading development and the contributions of home literacy experiences. *Journal of Experimental Child Psychology*, *93*(1), 63-93.

Liberman, I. Y., Shankweiler, D., & Liberman, A. M. (1989). The alphabetic principle and learning to read. [Monograph]. Retrieved from http://eric.ed.gov/?id=ED427291

Light, J. C., & Kelford Smith, A. (1993). Home literacy experiences of preschoolers who use AAC systems and of their nondisabled peers. *Augmentative and Alternative Communication*, *9*(1), 10 – 25.

Light, J., & McNaughton, D. (1993). Literacy and augmentative and alternative communication (AAC): The expectations and priorities of parents and teachers. *Topics in Language Disorders*, *13*(2), 33-46.

Light, J., McNaughton, D., Weyer, M., & Karg, L. (2008). Evidence-based literacy instruction for individuals who require augmentative and alternative communication: a case study of a student with multiple disabilities. *Seminars in speech and language* *29*(2), 120-132.

Machalicek, W., Sanford, A., Lang, R., Rispoli, M., Molfenter, N., & Mbeseha, M. K. (2009). Literacy Interventions for Students with Physical and Developmental Disabilities Who Use Aided AAC Devices: A Systematic Review. *Journal of Developmental and Physical Disabilities*, *22*(3), 219–240. doi:10.1007/s10882-009-9175-3

Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *The Annals of Mathematical Statistics*, 50-60.

Marshall, C. M., Snowling, M. J., & Bailey, P. J. (2001). Rapid auditory processing and phonological ability in normal readers and readers with dyslexia. *Journal of Speech, Language and Hearing Research*, *44*, 925–940.

McArdle, P. E., & Chhabra, V. E. (2004). *The Voice of Evidence in Reading Research*. Paul H. Brookes Publishing.

McNamara, J. K., Lankveld, J., van Vervaeke, S., & Gutknecht, N. (2010). An exploratory study of the associations between speech and language diffi culties and phonological awareness in preschool children, *3*, 1–18.

Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology*, *91*(1), 3.

Morais, J. (1991). Constraints on the development of phonemic awareness. In Brady, S.A., Shankweiler, D. P. (Eds.) *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 5-27). Routledge.

Mullen, E. M. (1995). *Mullen Scales of Early Learning.* Circle Pines, MN: AGS Publishing.

Kutner, M. A., Greenberg, E., & Baer, J. (2005). *National Assessment of Adult Literacy (NAAL): A first look at the literacy of America's adults in the 21st century*. National Center for Education Statistics, US Department of Education, Institute of Education Sciences.

Peeters, M., Verhoeven, L., van Balkom, H., & de Moor, J. (2008). Foundations of phonological awareness in pre-school children with cerebral palsy: The impact of intellectual disability. *Journal of Intellectual Disability Research*, *52* 68–78. doi:10.1111/j.1365-2788.2007.00986.x

Peeters, M., Verhoeven, L., de Moor, J., & van Balkom, H. (2009). Importance of speech production for phonological awareness and word decoding: The case of children with cerebral palsy. *Research in Developmental Disabilities*, *30*, 712–726. doi:10.1016/j.ridd.2008.10.002

Peeters, M., Verhoeven, L., de Moor, J., van Balkom, H., & van Leeuwe, J. (2009). Home literacy predictors of early reading development in children with cerebral palsy. *Research in Developmental Disabilities*, *30*, 445–461. doi:10.1016/j.ridd.2008.04.005

Perfetti, C. A., Beck, I., & Hughes, C. (1981). Phonemic knowledge and learning to read. In *meeting of the Society for Research in Child Development*, *Boston*.

Perfetti, C. A. (1985). *Reading ability*. New York: Oxford University Press.

Preston, J. L., & Edwards, M. L. (2010). Phonological awareness and types of sound errors in preschoolers with speech sound disorders. *Journal of Speech, Language, and Hearing Research*, *53*(1), 44–60. doi:10.1044/1092-4388(2009/09-0021).

Raven, J. C., Raven, J. E., & Hugh Court, J. (1956). *Coloured progressive matrices: sets A, AB, B.* Oxford Psychologist Press.

Rashid, F. L., Morris, R. D., & Sevcik, R. A. (2005). Literacy environment and reading achievement in children with reading disabilities. *Journal of Learning Disabilities*, *38*(1), 2–11.

Romski, M., Sevcik, R. A., Adamson, L. B., Cheslock, M., Smith, A., Barker, R. M., & Bakeman, R. (2010). Randomized comparison of augmented and nonaugmented language interventions for toddlers with developmental delays and their parents. *Journal of Speech, Language, and Hearing Research, 53*(2), 350-364.

Ruppar, A. L., Dymond, S. K., & Gaffney, J. S. (2011). Teachers' perspectives on literacy instruction for students with severe disabilities who use augmentative and alternative communication, *36*(3), 100–111.

Saunders, K. J., & DeFulio, A. (2007). Phonological awareness and rapid naming predict word attack and word identification in adults with mild mental retardation. *American Journal of Mental Retardation*, *112*(3), 155–66. doi:10.1352/0895 8017(2007)112[155:PAARNP]2.0.CO;2

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21*, 360-406.

Steele, A., Scerif, G., Cornish, K., & Karmiloff-Smith, A. (2013). Learning to read in Williams syndrome and Down syndrome: syndrome-specific precursors and developmental trajectories. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *54*(7), 754–62. doi:10.1111/jcpp.12070

Sutherland, D., & Gillon, G. T. (2007). Development of phonological representations and phonological awareness in children with speech impairment. *International Journal of Language & Communication Disorders*, *42*(2), 229-250.

Tallal, P. (1980). Auditory temporal perception, phonics, and reading disabilities in children. *Brain and language*, *9*(2), 182-198.

Torgesen, J., Wagner, R., & Rashotte, C. (1999). *Comprehensive test of phonological processing.* Austin, TX: Pro-Ed Publishing.

Treiman, R., & Zukowski, A. (1991). Levels of phonological awareness. In Brady, S.A., Shankweiler, D. P. (Eds.) *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 67-83). Routledge

Truxler, J. E., & O'Keefe, B. M. (2007). The effects of phonological awareness instruction on beginning word recognition and spelling. *Augmentative and Alternative Communication 23*, 164–176. doi:10.1080/07434610601151803

U.S. Department of Health and Human Services, National Institute on Child Health and Human Development. (2000) *Report of the National Reading Panel* (NIH Publication No. 00 4769). Retrieved fromhttp://www.nichd.nih.gov/publications/pubs/nrp/documents/ report.pdf

Vandervelden, M. C., & Siegel, L. (1999). Phonological processing and literacy in AAC users and students with motor speech impairments. *Augmentative and Alternative Communication*, *15*, 191–211. doi:10.1080/07434619912331278725

Vandervelden, M., & Siegel, L. (2001). Phonological processing in written word learning: assessment for children who use augmentative and alternative communication. *Augmentative and Alternative Communication*, *17*(March), 37–51. doi:10.1080/714043366

van Tilborg, A., Segers, E., van Balkom, H., & Verhoeven, L. (2014). Predictors of early literacy skills in children with intellectual disabilities: A clinical perspective. *Research in Developmental Disabilities*, *35*(7), 1674-1685.

Verucci, L., Menghini, D., & Vicari, S. (2006). Reading skills and phonological awareness acquisition in Down syndrome. *Journal of Intellectual Disability Research*, *50*, 477-491.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology*, *30*(1), 73–87. doi:10.1037//0012 1649.30.1.73

Wepman, J. M. & Reynolds, W. M. (1987). *Wepman's Auditory Discrimination Test, 2nd edition.* Los Angeles, CA: WPS Publishing.

Werker, J. F., & Tees, R. C. (1987). Speech perception in severely disabled and average reading children. *Canadian Journal of Psychology*, *41*(1), 48.

White, S., & Dillow, S. (2005). Key Concepts and Features of the 2003 National Assessment of Adult Literacy. NCES 2006-471. *National Center for Education Statistics*.

White-Schwoch, T., Carr, K. W., Thompson, E. C., Anderson, S., Nicol, T., Bradlow, A. R., ... & Kraus, N. (2015). Auditory processing in noise: a preschool biomarker for literacy. *PLOS Biology*, *13*(7), doi: 10.1371

Williams, K. (2014). *Phonological and Print Awareness Scale.* Torrance, CA: WPS Publishing.

Williams, P., & Stackhouse, J. (1998). Diadochokinetic skills: Normal and atypical performance in children aged 3–5 years. *International Journal of Language & Communication Disorders*, *33*(1), 481-486.

Wise, J. C., Sevcik, R. A, Romski, M. A., & Morris, R. D. (2010). The relationship between phonological processing skills and word and nonword identification performance in children with mild intellectual disabilities. *Research in Developmental Disabilities*, *31*(6), 1170–5. doi:10.1016/j.ridd.2010.08.004

Yorkston, K. M., Beukelman, D. R., Strand, E. A., & Bell, K. R. (1999). Management of Motor Speech Disorders in Children and Adults. Austin, TX: Pro-ED.

APPENDICES

Appendix A: Dysarthria Checklist

DYSARTHRIA CHECKLIST

(Yorkston, Beukelman, Strand & Bell, 1999)

Jaw
- ☐ Atrophy
- ☐ Reduced contraction
- ☐ Structural restrictions
- ☐ Adventitious Movement (circle one)
  Chorea Dystonia Fasciculations Hemiballismus
  Myoclonus Spasms Tics Tremors
- ☐ Other: ____________________

Lips
- ☐ Atrophy
- ☐ Adventitious Movement (circle one)
  Chorea Dystonia Fasciculations Hemiballismus
  Myoclonus Spasms Tics Tremors
- ☐ Resting asymmetry
- ☐ Inability to plose (/p/)
- ☐ Inability to vary tension
- ☐ Imprecise labial consonants
- ☐ Other: ______________________

Tongue
- ☐ Atrophy
- ☐ Adventitious Movement (circle one)
  Chorea Dystonia Fasciculations Hemiballismus
  Myoclonus Spasms Tics Tremors
- ☐ Resting asymmetry
- ☐ Inability to vary muscular tension
- ☐ Inability to plose (/t/)
- ☐ Imprecise consonant production
- ☐ Inability to differentiate vowels
- ☐ Other:_________________________

Participant ID#______________________

Velopharyngeal Function
- ☐ Nasal emission
- ☐ Hypernasality
- ☐ Resting Asymmetry
- ☐ Inability to sustain (/pop pop pop/)
- ☐ Adventitious Movement (circle one)
  Chorea Dystonia Fasciculations Hemiballismus
  Myoclonus Spasms Tics Tremors
- ☐ Other: __________________________

Respiration and Phonation
- ☐ Abnormal loudness (reduced/excessive)
- ☐ Loudness variation
- ☐ Shortness of breath
- ☐ Abnormal quality
  (breathy/hoarse/harsh/strained-strangled)
- ☐ Phonatory breaks
- ☐ Instability (mild/moderate/severe)
- ☐ Stridor (inspiratory/expiratory)
- ☐ Wet phonation
- ☐ Abnormal voluntary cough (weak/absent)
- ☐ Other:____________________

Scoring
0 = Not observed
1 = observed

Total Observed Characteristics:______

At least 1 characteristic in 2 or more categories = Dysarthria

Dysarthria (circle one): YES NO

Rate the overall severity of symptoms observed? (circle one)

Mild Moderate Severe

The following page may be used to further characterize the type of dysarthria based on characteristics observed.

Mark the type of dysarthria that best represents the cluster of characteristics observed:

______Spastic Dysarthria
harsh or strained-strangled voice
hypernasality
myoclonus/spasms of jaw
imprecise consonant production

______Flaccid Dysarthria
hypernasality
nasal emission
breathy respiration
imprecise consonant production
inability to differentiate vowels
fasciculation of tongue
atrophy of tongue
inability to sustain /pop pop pop/

______Mixed Spastic/Flaccid
Hoarse or strained-strangled voice
Imprecise consonant productions
Inability to differentiate vowels
Hypernasality
Nasal emission

_____Ataxic Dysarthria
Imprecise consonant production AND abnormal loudness
OR
Phonatory breaks (altered syllabic stress, prolonged intervals between syllables and words)

_____Hyperkinetic Dysarthria (Dystonia)
Dystonia
Phonatory breaks
Loudness variation
Distortion of vowels

_____**Hyperkinetic Dysarthria (Choreoathetosis)**
Abnormal exhalatory gusts of breath (Instability in respiration)
Abnormal loudness
Chorea (tongue) resulting in disintegration of articulation

_____**No characteristics of dysarthria observed**

Appendix B: Demographic Information

Demographic Information

Referral Source:______________________

General Information

Participant Number:________________ Date:_________________________

Primary Language Spoken in Home:____________ Secondary Language:__________

Child's date of birth:_________ Age:________ Sex: M F

CHILD

Ethnic Background: Hispanic_________ Non-Hispanic:_______

Hispanic or Latino: A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

Race: Please check all that apply:

American Indian/Alaskan Native_____ Asian_____ Native Hawaiian/Pacific Islander_____

Black or African American_____ White_____ Multiracial_____ Other_____ Unknown_____

PARENT 1

Sex: M F

Ethnicity: Hispanic_________ Non-Hispanic:_______

Race: Please check all that apply:

American Indian/Alaskan Native_____ Asian_____ Native Hawaiian/Pacific Islander_____

Black or African American_____ White_____ Multiracial_____ Other_____ Unknown_____

PARENT 2

Sex: M F

Ethnicity: Hispanic_________ Non-Hispanic:_______

Race: Please check all that apply:

American Indian/Alaskan Native_____ Asian_____ Native Hawaiian/Pacific Islander_____

Black or African American_____ White_____ Multiracial_____ Other_____ Unknown_____

Child's Diagnosis:____

(over)

Health/Development History

Birth Weight:__________ Was your child born prematurely?:_____________________________

If yes, how many months/weeks?:____

Ear infections: ____

Hearing:_____________________ When/Where tested?:_____________________________

Vision:______________________ When/Where tested?:_____________________________

My child understands (please provide examples):

words/routines__________________________ short phrases_____________________________

sentences____

My child primarily **communicates** by:____

Social History

Household composition:____

Exposure to other children and adults:____

Any challenging behaviors:____

Parent 1 Information

Birth date:______ Occupation_____________________ Title:_____________________________

Highest level of Education:

________High School Diploma
________Associates degree
________Bachelor's degree
________Master's degree
________Doctoral degree

Parent 2 Information

Birth date:______ Occupation:_____________________ Title:_____________________________

Highest level of Education:

________High School Diploma
________Associates degree
________Bachelor's degree
________Master's degree
________Doctoral degree

Appendix C: Home and School Literacy Survey

Participant ID#_________________

Home and School Literacy Survey
(Barton-Hulsey & Sevcik, 2016)

Directions: In this survey, you will be asked questions about your child's reading experiences at home and at school. You will also be asked questions about your own interest in reading.

There are no right or wrong answers.

Augmentative and Alternative Communication (AAC) is defined as any communication system designed to compensate for a severe expressive communication disorder (Beukelman & Mirenda, 1998).

Some examples of AAC include:

- Sign language, gestures, objects
- Alphabet boards, picture symbols
- Recordable devices such as Big Mack, Go Talk or Cheap Talk
- Computerized devices or Tablets that produce digitized or synthetic speech

Home Literacy Experiences

Directions: Please answer the following questions about your child's reading experience at home by circling your response on the scale provided.

Reading Books

1. Do you or another adult read books to your child?

Never/Rarely	On occasion	Weekly	Daily	Several books per day

If yes, at what age was your child when you began reading books to him/her?________________________

2. Does your child ask you to read to him/her?

Never/Rarely	On occasion	Weekly	Daily	Several times per day

3. Does your child independently point to or talk about pictures when you read stories?

Not currently	Has but rarely	Occasionally	A few times per story	Very frequently during story

4. How does your child usually communicate while reading books?

Facial expression	Gestures and/or pointing to items	Augmentative communication device	Vocalizations	Speech

5. Does your child ask questions about characters or events during story reading?

Not currently	Has but rarely	Occasionally	A few times per story	Very frequently during story

6. Does your child pretend to read the story in a book? (such as producing speech that is similar to the actual story in the book)

Never	Has but rarely	Weekly	Several times per week	Daily

7. Do you attempt to teach the names of the letters of the alphabet when reading?

Not currently	Have but rarely	Occasionally	A few times per story	Very frequently during story

8. Do you attempt to teach the sounds of the alphabet letters when reading?

Not currently	Have but rarely	Occasionally	A few times per story	Very frequently during story

9. In comparison to other activities, how would you rate your child's interest in books

0	1	2	3	4
Activity liked least				Favorite activity

10. If you frequently engage in book reading, what are your child's 3 favorite books?

____

Context of Reading, Technology and Media

11. How often do you read books that rhyme to your child (i.e., Brown Bear, Dr. Seuss, etc.)?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

12. How often do you read books that primarily name objects, colors or animals to your child?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

13. How often do you read books that have a simple story with characters and plot to your child?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

14. How often do you read books on a tablet/touchscreen device with your child (i.e., Ipad, Nook, Kindle, etc)?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

15. How often does your child independently read books on a tablet/touchscreen device?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

16. How often does your child play games involving letters and sounds on a tablet device or computer?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

17. How often does your child play games involving writing and/or typing letters on a tablet device or computer?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

18. How often does your child watch T.V. shows that explicitly focus on letter knowledge, sounds or words (i.e., Sesame Street, Word World, Between the Lions, etc.)?

Never/Rarely | On occasion | Weekly | Daily | Several times per day

Response to Print

19. Do you point out signs and words such as restaurant names or street signs to your child (i.e. McDonald's arches, Toys R Us logo, etc)?

Not currently | Have but rarely | Occasionally | Weekly | Daily

20. Does your child recognize familiar signs and logos such as restaurant names or street signs (i.e. McDonald's arches, Toys R Us logo, etc)?

Not currently | 1-2 | 3-4 | 5-6 | 6+

What signs or logos does your child know?____

____

21. Does your child ask for help in reading words such as signs, words on TV, or words on food packages?

Never/Rarely	On occasion	Weekly	Daily	Several times per day

22. Does your child read any words by sight?

Not currently	On occasion	Knows a word	Knows several words	Knows many words

23. Does your child read any words by sounding out the letters?

Not currently	On occasion	Some words	several words	many words

Language Awareness

24. Do you play rhyming games with your child?

Never/Rarely	On occasion	Weekly	Daily	Several Times per day

25. Does your child notice and say something when she/he hears words that rhyme? (i.e. that rhymes!)

Never/Rarely	On occasion	Weekly	Daily	Several Times per day

26. Does your child sing simple songs?

Never/Rarely	On occasion	Weekly	Daily	Several Times per day

Interest in Letters

27. Does your child identify letters of the alphabet? (i.e., point to the letter A when you ask him/her to?)

Never/Rarely	On Occasion	Weekly	Daily	Several Times per Day

28. Does your child attempt to make sounds for alphabet letters?

Not currently	Has but rarely	Occasionally	Frequently	Very Frequently

29. Does your child identify his/her name in print?

Not currently	Has but rarely	Occasionally	Frequently	Very Frequently

30. Do you do activities that involve tracing or copying letters or words?

Never/Rarely	On Occasion	Weekly	Daily	Several Times Per Day

Parent

31. Not including books required for school courses or your job how many books do you typically read in a year?

None	One or two	3 – 10	10 – 40	More than 40

32. How many magazine subscriptions do you have in your home (either mailed to your home or accessed via a tablet or e-reader device)?

None	1-2	3-5	6-10	More than 10

33. How many books of any kind are in your child's home (including novels, cookbooks, etc.)?

None	1 – 30	31 – 60	61 - 80	More than 80

34. How many children's books are in your child's home?

None	1 – 20	21 – 40	41 – 60	More than 60

35. In comparison to other activities you do with your child, reading is my:

0	1	2	3	4
Least favorite activity				Favorite activity

36. Reading together helps my child learn to read.

0	1	2	3	4
Strongly disagree				Strongly agree

37. Reading together helps my child learn language.

0	1	2	3	4
Strongly disagree				Strongly agree

School Literacy Survey

1. Does your child attend?(circle one): Preschool Kindergarten Does not attend school

2. If in school, how many days per week? 1 2 3 4 5

3. If in school, how many hours per week? _______________

Directions: If your child attends school, please answer the following questions on the scale provided by circling how often your child engages in each activity.

	Never/ Rarely	On occasion	Weekly	Daily	A few times per Day
Decoding and Phonological Awareness					
1. Plays rhyming games	0	1	2	3	4
2. Names the letters of the alphabet	0	1	2	3	4
3. Names the sounds of the alphabet letters	0	1	2	3	4
4. Practices sounding out simple words such as *cat, log,* or *fun* on flashcards	0	1	2	3	4
5. Uses an AAC device to sound out letter names or words during reading instruction	0	1	2	3	4
Technology and Media					
6. Reads books on a tablet/touchscreen and/or smartboard during class	0	1	2	3	4
7. Plays games involving writing and/or typing letters on a tablet device or computer	0	1	2	3	4
8. Plays games involving letters and sounds on a tablet device or computer during class	0	1	2	3	4
Word Recognition and Vocabulary Development					
9. Participates in sight word instruction based on commonly occurring words in the community and home	0	1	2	3	4
10. Participates in sight word instruction for high-frequency words (e.g. *is, of, the, and*)	0	1	2	3	4
11. Defines words during reading instruction	0	1	2	3	4
12. Identifies relevant phrases or words using an AAC system during reading instruction	0	1	2	3	4

	Never/ Rarely	On occasion	Weekly	Daily	A few times per Day
Writing					
13. Traces letters	0	1	2	3	4
14. Copies simple words	0	1	2	3	4
15. Spells words using a keyboard	0	1	2	3	4
16. Spells words on an AAC device with voice output	0	1	2	3	4