Alphabet Knowledge and Phonological Awareness in Children with Speech Sound Disorder

DISSERTATION

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By
Sherine Tambyraja
Graduate Program in Speech and Hearing Science

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Dissertation Committee:

Rebecca McCauley, Advisor
Laura Justice
Monique Mills
Shayne Piasta
Abstract

Considerable evidence has shown that kindergarten measures of phonological awareness and alphabet knowledge are significant predictors of word decoding ability in many typically developing children. Many children with speech sound disorder (SSD) have been found to exhibit poor phonological awareness; however, very few studies have provided a thorough investigation of their knowledge about letter names and letter sounds. The current study was thus designed to examine alphabet knowledge and phonological awareness, and their relationships, in kindergarten children with SSD (n = 16). Alphabet knowledge was assessed by comparing accuracy in naming of all 26 letter names and letter sounds, and was further evaluated to determine differences as a function of letter name category. Two levels of phonological awareness on an elision task (larger vs. smaller units) were compared. Finally, correlations between alphabet knowledge and phonological awareness levels were calculated. Overall, participants knew more letter names than letter sounds, and their letter sound knowledge varied according to letter name categories. Participants exhibited greater accuracy when deleting larger sized units, as compared to smaller units. Furthermore, children whose speech errors were atypical or severely delayed for their age had the lowest scores on the elision task, but performed as well as others on both measures of alphabet knowledge. Outcomes from this study suggest that some children with isolated SSD would have acquired knowledge about letter names and sounds in their kindergarten year, but may encounter difficulty in developing deeper levels of phonological awareness.
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Vita

May 1997 .............................................. B.A. English, Economics, Rutgers University

May 2003 .................................................. M.A. Education, Teachers College

2003-2006 ............................................ University Research Associate, CUNY

2009-present .......................................... Graduate Trainee, Department of Speech and Hearing, The Ohio State University

Fields of Study

Major Field: Speech and Hearing Science
Table of Contents

Abstract .............................................................................................................................................. ii

Acknowledgments ............................................................................................................................ iv

Vita....................................................................................................................................................... v

List of Tables ....................................................................................................................................... vii

List of Figures ..................................................................................................................................... viii

Chapter 1: Introduction ........................................................................................................................ 1

Chapter 2: Literature Review .............................................................................................................. 5

  Theoretical Framework: The Simple View of Reading ................................................................. 6

  Alphabet Knowledge in Typically Developing Children .............................................................. 10

  Phonological Awareness in Typically Developing Children ......................................................... 13

  Children with Speech Sound Disorders ......................................................................................... 20

  Levels of Phonological Awareness in Children with SSD ........................................................... 27

  Alphabet Knowledge in Children with SSD ............................................................................... 30

  Purpose of the Study ......................................................................................................................... 34

Chapter 3: Methods ............................................................................................................................. 37

  Participants ....................................................................................................................................... 37

  Inclusion Criteria ............................................................................................................................... 38

  Study Procedures ............................................................................................................................... 39

  Reliability ......................................................................................................................................... 50

  Data Analysis .................................................................................................................................... 51

Chapter 4: Results ............................................................................................................................... 53
List of Tables

Table 1. Mean standard scores standardized assessments of children with SSD……..40

Table 2. Letter name categories…………………………………………………………………….46

Table 3. Descriptive statistics for alphabet knowledge and phonological awareness…..54

Table 4. Pearson correlation coefficients between descriptive variables, phonological awareness, and alphabet knowledge …………………………………………………64

Table 5. Pearson correlation coefficients between levels of phonological awareness and categories of alphabet knowledge……………………………………………..66
List of Figures

Figure 1. Mean percent correct and standard error for LSK across four letter name categories. .................................................................................................................. 57

Figure 2. Mean percent correct and standard error for items of the Catts deletion task... 58

Figure 3. Mean percent correct and standard error on Catts deletion task by children with GFTA scores above and below 80 ................................................................. 61

Figure 4. Mean percent correct and standard error on Catts deletion task by children demonstrating more delayed and atypical errors and those demonstrating minimally or moderately delayed errors.......................................................... 62
Chapter 1: Introduction

The predictive nature of both alphabet knowledge (AK) and phonological awareness (PA) to reading ability has been one of the most consistent findings in early literacy research (Adams, 1990; Bishop, 2003; Bradley & Bryant, 1993; Ehri & Roberts, 2006; Lonigan, Burgess and Anthony, 2000). The contributions from both phonological awareness and alphabet knowledge for reading are quite logical, in that graphemes (letters) represent phonemes (individual sounds), which permits the sounding out of words (Foy & Mann, 2003; Scarborough, 2001). If a child does not have an understanding that these small sound structures are separable, or does not know about the letters and the associated sounds that represent that information, the child will not be able to make connections for reading. A rich body of literature has also shown strong correlations between alphabet knowledge and phonological awareness (e.g., Aouad & Savage, 2009; Burgess & Lonigan, 1998; Carroll, 2004; Foy & Mann, 2006; Johnston, Anderson & Holligan, 1996; Manolitsis & Tafa, 2011; McBride-Chang, 1999), particularly at deeper levels of phonological awareness (i.e., those involving awareness of finer details of phonologic structure). As such, children who demonstrate strong phonological awareness often have greater knowledge of letter names and sounds.

Although numerous studies have examined how alphabet knowledge (of letter names and sounds) and phonological awareness (of syllables, rimes, and phonemes) develop in typically developing children, the literature about children with deficits in one
or both of these skill areas is less extensive. Growing evidence suggests that many children with speech sound disorder (SSD) exhibit poorer phonological awareness when compared to typically developing children (Anthony et al., 2011; Bird, Bishop & Freeman, 1995; Gillon, 2005; Rvachew, Ohberg, Grawburg, and Heyding, 2003; Treiman, Pennington, Shriberg & Boada, 2008), and longitudinal studies have reported that some children with SSD eventually demonstrate poorer reading abilities (e.g., Nathan, Stackhouse, Goulandris, & Snowling, 2004; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004). However, very few studies have carefully examined the construct of alphabet knowledge in young children with SSD (Anthony et al., 2011; Treiman et al., 2008) to understand whether deficits in phonological awareness may affect their acquisition of alphabet knowledge. Furthermore, studies investigating phonological awareness in children with SSD are not conclusive about whether their poorer performances are due to a generally impaired phonological system, or are specific to phoneme awareness. As such, whether, or to what extent, these two critical predictors of reading success (i.e. alphabet knowledge and phonological awareness) correlate in children with SSD remains largely unexplored.

The present study sought to address this gap in knowledge by examining differences between letter name knowledge (LNK) and letter sound knowledge (LSK) and examining whether knowledge about letter names and sounds differed for specific categories of letters than others, particularly letters with names that impart information about its associated sound (i.e., the sound of the letter b is contained in the initial phoneme of the letter name) and letters that do not convey that information (e.g., w).
Because those differences in LSK that can be attributed to letters with and without a name-sound association may or may not indicate phonemic awareness, this study also compared differences in children’s ability to manipulate large (i.e., words and syllables) and small (i.e., phonemes) phonological units in order to understand whether children with SSD might have generally poor phonological awareness, or difficulties specific to phoneme awareness. By individually assessing the elements of the two aforementioned skills, this study further sought to determine the strength of the relationships between alphabet knowledge (LNK and LSK) and levels of phonological awareness.

Four research questions addressing letter name knowledge, letter sound knowledge, and phonological awareness were addressed in this dissertation research:

(1) Do children with SSD differ in their knowledge of letter sound knowledge (LSK) and letter name knowledge (LNK)?

(2) Does their LNK and LSK differ by letter name categorization reflecting the way in which the letter name encodes the sound associated with the letter?

(3) Do children with SSD perform differently on two parts of a phonological elision task, in which the size of the deleted structure varies (words and syllables versus phonemes)?

(4) Is children’s alphabet knowledge (both LNK and LSK) related to their accuracy on a phonological elision tasks (involving deletion of words and syllables and single sounds)?

The results of this study have the potential to contribute important information about the early decoding skills of young children with SSD that may be utilized by both
researchers and clinicians. Because this study provides a full description of alphabet knowledge and phonological awareness in children with isolated SSD, researchers may obtain a better understanding of which aspects of these skills are strengths or areas of weakness for this population. Clinicians may find this information useful as well, in order to consider interventions that might be particularly suited for children with deficits in one area. Finally, this information may be used as a foundation for future work to understand how these skills develop in children with SSD, and how their development might be supported to aid in their early reading success.

The remaining chapters of this dissertation describe the background, rationale, methods and outcomes of this study. Specifically, Chapter 2 provides a review of the relevant literature, including the theoretical foundations and empirical evidence supporting the importance of these two skills as seen in typically developing kindergarten children. A review of the existing literature regarding what is currently known about these skills in children with SSD is provided as a background to this study’s four research questions. Chapter 3 includes a description of the study methods, describing the participants, study measures and procedures, and analytical techniques. The results of those analyses are detailed in Chapter 4. The final chapter discusses this study’s key findings and broader implications.
Chapter 2: Literature Review

This chapter is intended to provide theoretical and empirical rationale for the research questions of the present study. Initially, the two core constructs to be studied are described in terms of their role in the development of word decoding skills within The Simple View of Reading (Gough & Tunmer, 1986). Next, the current evidence for how alphabet knowledge and phonological awareness develop and correlate is explored for typically developing children. Finally, the results of similar research conducted on children with SSDs are reviewed as a means for identifying key gaps in the research base that provided the focus for this work.

**Importance of Alphabet Knowledge and Phonological Awareness**

A recent meta-analysis (National Early Literacy Panel, 2008) reported that alphabet knowledge (AK) and phonological awareness (PA) represented two of the six early literacy variables that best predicted later reading achievement, where AK can be defined as the ability to identify the names (LNK) and sounds of letters (LSK), and phonological awareness (PA), as the awareness and ability to analyze aspects of spoken language, such as words, syllables, and phonemes. Furthermore, studies describing a predictive relationship between phonological awareness and reading ability have determined that awareness and segmentation ability at the level of the phoneme are most critical and predictive of later reading ability (Bradley & Bryant, 1983; Catts, 1993; Nation & Hulme, 1997). The NELP’s review of the literature determined that these
predictors remained significant even when accounting for differences due to IQ and socioeconomic status.

The importance of these two predictors to later reading ability underscores the need to understand how children with a range of ability and skill level acquire the tools and proficiencies required for successful reading. Use of a theory of reading can help explain both why these skill domains are such important predictors and how children’s skills in other areas of speech and language may contribute to or interact with them.

**Theoretical Framework: The Simple View of Reading**

There are several existing theories that describe the processes and skills required for learning to read (e.g., Seymour & Duncan, 1997; Stanovich, 1980). The Simple View of Reading (Gough & Tunmer, 1986), which was chosen for use in the present research, outlines a succinct framework for understanding the principal components of reading comprehension, and as such helps to identify which children may be at risk for reading difficulties. The model predicts that reading comprehension relies on two distinct abilities – word recognition and linguistic comprehension. Both are necessary, but neither is sufficient, for successful reading. Decoding translates printed words into language; linguistic comprehension is needed to understand the words that have been decoded. As such, reading can be understood in mathematical terms, as Reading (R) = Decoding (D) x Comprehension (C), where D and C are assigned values from 0-1. If a child has either no decoding or comprehension skills (where either D or C=0), then R would equal 0. Although not all studies have found that reading comprehension is necessarily a product of decoding and listening comprehension (e.g., Savage, 2006), or that reading
comprehension relies only on those two skills (e.g., Joshi & Aaron, 2000), considerable evidence has shown that both decoding and comprehension impart substantial and unique contributions to reading (Adlof, Catts, & Lee, 2010; Catts, Hogan, & Adlof, 2005; Kendeou, Savage, & van den Broek, 2009).

Word recognition and comprehension abilities each correlate significantly with reading comprehension (Adlof, et al., 2010), but are not necessarily correlated with each other (Kendeou, et al., 2009), supporting the notion that these abilities develop from different skill sets. Furthermore, both word decoding and reading comprehension are essential to successful reading comprehension, but the relative importance of the two skills may change over time (Catts, et al., 2005). Catts et al. suggest that decoding skills are initially of greater consequence, as most children have linguistic knowledge that exceeds their decoding abilities because the content they are reading is quite simple. By about fourth grade, however, the ability to decode known and unknown words should be well established, and thus greater language comprehension is needed to derive meaning from the decoded words.

**What contributes to decoding skills?** Gough and Tunmer (1986) propose that the act of decoding and recognizing printed words depends on understanding both letter-sound correspondences and spelling-sound correspondences. Thus, two critical skills that underlie the development of word decoding ability are alphabet knowledge, including knowledge about letter names (LNK) and their associated sounds (LSK), and phonological awareness (PA), or sensitivity to sound structures that facilitate connections between graphemes and phonemes in order to read novel, or unknown, words (Hoover &
Gough, 1990). The essential nature of early decoding skills is underscored in longitudinal data from Adlof et al. (2010), who found that kindergarten performance on both phoneme deletion and letter identification tasks strongly predicted reading ability in second grade, and that phoneme deletion was the best predictor of reading ability in a group of 433 eighth graders.

**Evidence for the Simple View of Reading.** Numerous studies support the idea that both alphabet knowledge and PA, particularly phoneme awareness, make important contributions to decoding ability (e.g., Catts, 1993; Savage & Carless, 2005). Studies investigating predictive relationships between phonological awareness and word reading skills determined that awareness and segmentation ability at the level of the phoneme is most critical and predictive of later reading ability for English-speaking children (e.g., Catts, 1993; Nation & Hulme, 1997) as well as those learning to read in other alphabetic languages, including Spanish, Slovak, and Czech (Caravolas et al., 2012). Research has also shown that a sound deletion task (e.g., Catts, Adlof, & Weismer, 2006; Georgiou, Parilla, & Papadopoulos, 2008) in which children are asked to remove segments of a spoken word (either a syllable or a phoneme) in order to create a new word is particularly powerful at predicting reading ability. Furthermore, a recent study by Hulme, Bowyer-Crane, Carroll, Duff, & Snowling (2012) showed that that instruction of both phoneme awareness and LSK had a direct and positive impact on word-reading ability in children between the ages of 5 and 6, highlighting the direct effects that phoneme awareness and LSK can have on word reading ability.
Research aimed at classifying subgroups of poor readers is consistent with identifying phoneme awareness and alphabet knowledge as critical indicators of reading success. Catts, Adlof and Wesimer (2006) measured the language comprehension and phonological processing skills of eighth-graders \((n = 182)\), who were either “poor comprehenders” \((n = 57)\), “poor decoders” \((n = 27)\) or typically developing \((n = 98)\). Those labeled as poor decoders had significantly lower scores on three PA tasks (phoneme deletion, a pig Latin task and nonword repetition), although their language comprehension scores were similar to typically developing children. Conversely, those labeled as poor comprehenders had PA scores comparable to typically developing children, but significantly poorer language comprehension. Furthermore, retrospective data available for these participants from kindergarten, 2\(^{nd}\) and 4\(^{th}\) grade showed that these differences in skill ability had been present and consistent from 2\(^{nd}\) grade onwards even though both groups demonstrated equally low PA in kindergarten. Thus, kindergarten measures of phoneme awareness may be highly indicative of eventual reading difficulties, in either decoding or comprehension.

The tenets of the Simple View of Reading provide a framework for understanding which children may be at risk for reading difficulties. Children in the early phases of developing word decoding skills who demonstrate deficits in any of the underlying skills that support reading comprehension may encounter reading difficulties at a later stage. Given that context, the purpose of the current study is to focus on the skills required for decoding, with emphasis on whether these skills may be challenging for children with hypothesized deficits in phonological awareness. Specifically, this study aims to
examine two predictors of decoding ability—alphabet knowledge and phonological awareness—using measures often utilized in assessing these skills (letter names, letter sounds, and deletion tasks). Prior to a discussion of what is specifically known about AK and PA in children with SSD, the following sections provide an overview of what is known about each of these skill domains in typically children.

**Alphabet knowledge in typically developing children**

Alphabet knowledge refers to knowledge about both letter names and letter sounds. Letter name knowledge (LNK) refers to the ability to recognize and identify the letters of the alphabet; whereas letter sound knowledge (LSK) refers to the ability to recognize and pronounce the sounds that represent each letter of the alphabet. Although researchers often combine scores from LNK and LSK assessments, and may also refer to it collectively as letter knowledge, several authors have argued that these two aspects of alphabet knowledge should be assessed and reported separately, because they are different constructs involving unique skills (e.g., Mann & Foy, 2003; McBride-Chang, 1999).

**Letter names and letter sounds.** Most studies conducted in the United States that test letter names and sounds separately have found that initially, children demonstrate greater knowledge about letter names than letter sounds (e.g., Ellefson, Treiman & Kessler, 2009; Kim et al., 2010; Treiman et al., 2008). McBride-Chang (1999) notes that there are many opportunities for young children to learn letter names prior to entering kindergarten, from books, songs, television programs, and pre-school experience. The task for many kindergartners, then, is learning about letter sounds
Data has shown that children learning to read in alphabetic orthographies can utilize their knowledge about letter names to learn letter sounds (Share, 2004, Treiman, Weatherston, & Berch, 1994); thus suggesting a legitimate advantage to learning names first. There is evidence, however, that this commonly reported pattern in U.S. children is a product of instructional conventions that initially focus on teaching letter names before teaching children about letter sounds. Kindergarten children in the United Kingdom and Greece, for example, demonstrate greater initial LSK than LNK, because teaching of letter sounds is initially emphasized over letter names in those countries (Ellefson et al., 2009; Manolitsis & Tafa, 2011).

**Letter name categories.** Research examining LSK in young children has revealed common patterns of acquisition that reflect phonological properties of letter names (Foy & Mann, 2006; Kim et al., 2010; McBride-Chang, 1999; Piasta & Wagner, 2010; Treiman, Tincoff, Rodriguez, Mouzaki & Francis, 1998; Treiman et al., 2008; Treiman et al., 1994). For example, work by Treiman and colleagues found that the phonological structure of letter names guides children in their learning of letter sounds. Many consonant letters in the English alphabet have a consonant-vowel (CV) syllable structure, such as b, d, and p and the names of these letters contain the associated sound in the syllable’s initial phoneme. Letters that have a vowel-consonant (VC) structure, such as f, l, and m, also contain the associated sound, but in the syllable’s final phoneme. Fewer letter names have no association with their sounds (NA), such as h and w. Studies investigating children’s knowledge of individual letter sounds has found that many typically developing children demonstrate greater knowledge about the sounds of CV
letters, followed by knowledge about VC letters, with knowledge about NA letters being the poorest (Foy & Mann, 2006; Kim et al., 2010; Treiman, et al., 1998; Treiman et al., 2008). In other words, children seem to demonstrate strongest knowledge about the letter sounds that can be deciphered by knowing the letter name. Researchers describing this commonly reported pattern of LSK acquisition explain that this outcome is a result of children using their developing PA abilities and the phonological structure of letter names to derive information about letter sounds. Dodd and Carr (2003), for example, argue that LSK depends on both knowledge of letter names and a degree of phoneme awareness. They suggest that in order to understand letter sound correspondences, children must have figured out how to segment individual sounds (i.e., phonemes).

However, not all studies have found significant differences between knowledge of CV and VC letter sounds (e.g., Share, 2004), or even differences between CV and vowel letter sounds (e.g., Evans, Bell, Shaw, Moretti & Page, 2006). Particularly, some studies have shown that effects of alphabet instruction can influence patterns of letter sound learning. Share (2004) tested whether children use letter names to derive letter sounds in a study with Israeli kindergartners. Children were taught the names of pseudoletters in two conditions – using English letter names, or Hebrew words that were visually related to the shape of the pseudo letter (i.e., the name for the pseudo letter bridge was the shape of a bridge). Children were then taught the associated letter sound, which was associated with the English letter name. Children who learned letter names that were associated with the sound showed an advantage in letter sound learning. Furthermore, there was no difference in learning letter sounds that were CV or VC syllables. Piasta and Wagner
(2010) reported similar outcomes in that children receiving instruction about letter names and sounds showed no significant differences in their knowledge about CV and VC sounds, although both were higher than NA letters.

Despite the fact that not all studies have found significant differences between all categories of LSK, the results are similar in showing the possible role of phonological awareness, particularly phonemic awareness, for deriving information about letter sounds from some categories of letter names. These outcomes support the notion that letter-sound correspondence and phoneme awareness may connect and contribute to word decoding, as outlined in the Simple View of Reading. The following section describes the construct of phonological awareness and how it develops in typical development.

Phonological Awareness in Typically Developing Children

*Phonological awareness* (PA) is used as an umbrella term to describe the skills required for the sensitivity and ability to manipulate a range of sound structures in spoken language, including words, syllables and phonemes (Whitehurst & Lonigan, 1998). The term *phonemic awareness* refers to one subset of phonological awareness, namely, the specific ability to analyze and manipulate sounds at the level of the phoneme, or the smallest functional unit of language. Throughout this document, PA will refer to the term phonological awareness will be used to refer to these skills, and specific references to phonemic awareness will be used as appropriate. As the evidence discussed in this section indicates, the distinction between these two constructs is important because not all aspects of PA appear to be equally important as predictors of future reading outcomes.
Development of phonological awareness. Several theories of how phonological awareness develops in children are similar in proposing that the process involves a progression towards narrower, more refined attention to phonological details, and thus more distinguished phonological representations (e.g., Menn, 1983; MacNeilage & Davis, 1994; Studdert-Kennedy, 1987), or mental representations for categories of phonological information. As children’s vocabularies increase, these representations are become more fine-tuned from whole words, to syllables, to onsets and rimes, and eventually phonemes. Theories on how children’s performances on tasks tapping phonological awareness, therefore, suggest a similar progression of ability. Goswami and Bryant (1990) argued that children can perform well on syllable awareness tasks at an early age, followed by onset and rime awareness, and finally phonemes. Gombert (1992), however, suggested that the progression could instead be characterized in terms of larger and smaller phonological units, based on evidence that children do not always show a linear development from awareness of syllables to rimes. Rather, children seem initially adept at manipulating and analyzing larger sized structures before gaining proficiency with smaller structures.

Evidence from typically developing children generally supports the theory that the level of detail that children recognize is gradually fine-tuned (e.g., Anthony, Lonigan, Driscoll, Phillips, & Burgess, 2003; Anthony & Francis, 2005; Dodd & Gillon, 2001). Carroll, Snowling, Hulme and Stevenson (2003) tested 67 typically developing preschool children three times over the course of one year on measures of syllable, rime and phoneme awareness, as well as speech, language and LSK. Children showed the
expected pattern of development such that their ability on syllable and rime awareness preceded phoneme awareness, but did not demonstrate significant differences on the syllable versus rime awareness tasks. Hesketh, Adams and Nightingale (2000), however, found a different pattern of ability in their sample of 59 typically developing preschoolers, when tested on measures of phoneme blending, rhyme matching, word initial segmentation and matching, word initial matching and phoneme deletion. Specifically, children’s scores on all phonological awareness tasks (i.e., syllable, rimes, and phoneme) were similar regardless of the size of the phonological unit requiring manipulation, with the exception of the phoneme deletion task, for which children’s scores were significantly poorer. Although their study did not specifically test for differences in ability related to the size of phonological units, their results indicate that the mental operations (i.e., deletion, segmentation, blending) required to complete some tasks may influence performance as much as, or more, than the level of structure (i.e., syllable, phoneme) being manipulated.

Despite some variation in the literature, it is generally accepted that children’s phonological development progresses from larger to smaller units of representation and awareness, and that this increased awareness of smaller phonological units aids in understanding the relationship between letters and phonemes, such as needed in learning about letter sounds (e.g., Byrne & Fielding-Barnsley, 1989; Scarborough, 2001; Share, 2004). Whether phoneme awareness is needed for acquiring letter sound knowledge or whether learning about letter sounds helps children develop deeper levels of phoneme awareness has been debated in the literature (e.g., Burgess & Lonigan, 1998). Numerous
studies have sought to identify whether one skill precedes the other, or whether the relationship between alphabet knowledge and phoneme awareness is reciprocal. The following section briefly discusses the findings of these studies.

**Relationships between AK and PA in Typically Developing Children**

As discussed above, several studies describing the pattern of letter sound acquisition in typically developing children suggest a relationship between phonological awareness and both types of alphabet knowledge. Learning about letter names likely paves the way for understanding printed letters as objects capable of being reflected on, manipulated, etc. Nonetheless in order to utilize that information for reading, understanding how those letters correspond to individual spoken language sounds is essential.

**Phonological awareness and LSK.** A large body of research investigating the acquisition of LSK in typically developing children has found strong correlations between PA and LSK (e.g., Blair & Savage, 2006; Carroll, 2004; deJong, 2007; Foy & Mann, 2006; Johnston, Anderson & Holligan, 1996; Kim et al., 2010; Share, 2004). However, study findings vary when considering the unit of phonological analysis. Manolitsis and Tafa (2011), for example, found significant correlations between numerous PA levels (syllables, onsets, and phonemes) and LSK in 89 Greek-speaking kindergartners. Foy and Mann (2006) also found that both rhyme awareness and phoneme awareness were significant predictors of LSK. Similarly, Treiman et al. (2008) found that correlations between composite PA scores from four tasks (assessing rhyme, syllable and phoneme awareness) and LSK were significant in a group of 5-6 year-old
children with varying speech and language abilities. From these studies, it might be inferred that any level of phonological awareness will bear some relationship to LSK. However, studies examining specific types of PA tasks suggest otherwise. For example, a training study by de Jong (2007) determined that scores on an initial sound matching task, a measure of phoneme awareness, were more strongly correlated with letter sound learning than scores on a rhyme awareness task for 41 typically developing kindergartners. This relationship remained significant even after factors of age, vocabulary and letter name knowledge were taken into account. Carroll (2004) found a strong relationship between LSK and a phoneme completion task, in which children are shown a picture of an object and told part of its name, and asked to complete the word (i.e., a child sees a picture of a gate and hears /gai/, and should respond with /t/).

Relationships between LSK and phoneme deletion tasks were significant, but not as strong as those between LSK and the phoneme completion task, which may have been due to the overall low scores for this task. The author argued that the phoneme completion task specifically requires the identification and isolation of phonemes, which may be the mental operation that is most similar to that of associating letter names and letter sounds. Share (2004) reported similar outcomes such that only tasks involving initial phoneme isolation, as opposed to final phoneme isolation, correlated significantly with Israeli kindergartners’ letter sound learning. Taken together, although several studies have shown a significant correlation between LSK and PA, there is substantial evidence that those relationships may be particularly strong with phoneme awareness.
PA and LSK within letter name categories. The studies above all described the relationships between levels of phonological awareness and children’s overall scores on a LSK task. However, there are data to suggest that those relationships may differ within the construct of letter name categories, according to letter name categories. Specifically, some authors (e.g. Evans et al., 2006; Treiman et al., 1994) have suggested that letter names can be categorized according to their phonological structure (e.g., CV, VC, NA and vowels). As such, LSK of CV and VC letter names might bear stronger relationships to phonological awareness than NA letters, since the letter sound can be realized by isolating the sound from the letter name. However, findings with respect to these differential relationships vary considerably. As described above, Treiman et al. (2008) reported significant and similar correlations between pooled PA results (rhyme and sound matching) and LSK of three letter name categories (CV, VC and NA) for a group of 5-6 year-olds that included children with varying degrees of speech and language impairment as well as typically developing children.

Kim et al. (2010) determined that a composite PA score (from onset-rime and phoneme blending tasks) contributed to children’s LSK for different letter name categories, particularly when children knew the names of those letters, providing support for the idea that PA aids in deriving the appropriate letter sounds from the letter name. The contribution of PA was particularly strong for CV and VC letters when the letter names were not known, suggesting that without explicit knowledge about letter names, children rely on phonological awareness skills to derive the associated letter sound. Piasta and Wagner (2010) also reported correlations between phonological awareness
(phonological elision and blending tasks) and all letter name categories in their sample of 20 preschool children who received a combined letter name and sound training. Children in the control condition exhibited variable relationships between LSK and PA; those with low PA learned very few letter sounds, and those with higher PA were more likely to learn CV letter sounds over all other categories. Their study not only highlights the impacts of letter name and letter sound instruction, but also suggests that in the absence of direct instruction, children’s abilities in deriving letter sounds depend on their PA. It is noted, though, that the children in their study were young (mean age = 3.77), and had relatively low LSK overall.

Although several studies note particularly strong relationships between PA and LCK of CV and VC letters, Foy and Mann (2006) found that knowledge of NA letter sounds was the best predictor of ability on phoneme manipulation tasks for a group of 4-6 year old typically developing children. The authors explained that children who possess knowledge about NA letter sounds are likely those who have the most highly developed phonological awareness skills, although it is also likely that those children were the most mature in their development and knowledge acquisition in both domains.

In summary, the totality of studies described above suggests that many typically developing children may utilize phonological awareness skills to some degree to acquire knowledge of letter sounds, particularly if they possess knowledge of letter names. Although several studies suggest that phonological awareness at the level of the phoneme is needed to segment letters with CV and VC syllable names in order to obtain the appropriate letter sound that is associated with that letter name, other studies have found
that awareness at the level of onset and rime is sufficient for identifying some letter sounds. Similarly, although the majority of studies note that AK precedes PA, such that children with very low levels of AK are unable to complete PA tasks (e.g. Johnston et al., 1996), other studies have found that some children show some degree of PA in the absence of LSK (e.g., Blair & Savage, 2006).

**AK and PA in children with poor PA skills**

Studies examining PA and LSK in children with poor phonological awareness skills provide another perspective for considering these relationships. Although some studies suggest that children with lower PA are just as likely to acquire LSK in the predicted pattern as compared to those with higher PA (deJong, 2007; Kim et al., 2010; Levin, Shantil-Carmon, & Ornit, 2006; Treiman et al., 2008), evidence from alphabet training studies shows that children with very low or poor PA abilities can acquire LSK with explicit instruction, particularly for letters in the CV category (Cardoso-Martins, Mesquita, & Ehri, 2011; Castles, Coltheart, Wilson, Valpied, & Wedgwood, 2009; de Graaff, Saskia, Verhoeven, Bosman, & Hasselman, 2007) but have difficulty with other letter categories. Therefore, it would be valuable to know if children with SSD, who are considered to be at risk for poor PA, are also at risk for deficits in LSK. To date, very few studies have examined the construct of AK--both LNK and LSK--in children with SSD; thus, how these critical predictors of literacy are related for these children is not well understood.

**Children with Speech Sound Disorders**
Defining speech sound disorders. The term *speech sound disorder* (SSD) is used to refer to a heterogeneous group of children who exhibit communication difficulties related to speech sound production and use and whose speech sound errors cannot be attributed to significant impairment in cognitive, sensory, motor, or structural difficulties (Shriberg, 2003). Prevalence estimates of SSD vary considerably, likely due to the range of diagnostic criteria used to identify and define SSD (Shriberg, Tomblin, & McSweeney, 1999). Shriberg et al. found that 3.8% of 6 year olds demonstrated a “speech delay” within their sample of 1,328 children, where speech delay was defined by Shriberg et al. use to refer to disorders often described by others as phonological disorders, rather than articulation disorders. Law, Boyle, Harris, Harkness, & Nye (2000) reviewed several prevalence studies and found a range in reports from 2 to 14%, although the authors concede that these estimates may vary according to the various ways different authors may define SSD. In nearly all reports, studies show that boys are more likely to have a SSD than girls (Lewis et al., 2011; Shriberg et al., 1999).

Children with these problems vary considerably in the degree to which their speech is affected, from those with distortions affecting a small number of sounds (a subgroup often referred to as having an articulation disorder) to those with errors that involve entire classes of sounds and syllable structures (a subgroup often referred to as having a phonological disorder). Whereas children with articulation disorders exhibit few concomitant disorders and typically do not experienced reduced intelligibility, those with phonologic impairments are at risk for both reduced intelligibility and a variety of concomitant communication disorders, including deficits in expressive and receptive oral
language (Shriberg & Kwiatowski, 1994) as well as in literacy (Broomfield & Dodd, 1995; Larrivee & Catts, 1999; Schuele, 2004).

**Risks to reading in children with SSD: The influence of language impairment.** Several longitudinal studies have suggested that children with isolated speech sound disorders (SSD) are unlikely to encounter reading difficulties (e.g., Bishop & Edmundson, 1987; Catts, 1993; Hesketh, 2004; Snowling, Bishop & Stothard, 2000). Rather, these studies, along with the body of research that has investigated which subgroups of children with SSD encounter later reading difficulties, have largely concluded that those with concomitant language impairment are at greatest risk (e.g. Bird et al., 1995; Catts, 1993; Larrivee & Catts, 1999; Raitano et al., 2004; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007). Sices et al. (2007) examined 125 preschool children with SSD (defined by GFTA scores below 10th percentile and exhibiting at least 3 phonological processes), 53% of whom had a comorbid LI, to ascertain which group was at greatest risk for lags in developing early literacy skills. It was found that those in the comorbid group had lower phonological awareness, early reading and early writing scores than those with isolated SSD. The authors concluded that language skills, not articulation ability, predicted early reading and writing abilities. However, in this study, as in others, the group of children with concomitant SSD and LI also had significantly lower performance IQ, and overall had more severe speech output difficulties than those with normal receptive language ability. Thus, understanding the precise impacts from SSD and LI on early reading skills is complicated by the fact that many children with
both deficits may actually have additional difficulties impacting their early reading
development.

**Risks to reading in children with SSD: The influence of persisting speech problems.** Although children with concomitant speech and language problems may be likely to experience difficulty in the development of early reading skills, the *critical age hypothesis*, which was proposed by Bishop and Adams (1990) and has received support in some recent work (Raitano et al., 2004; Nathan et al., 2004), suggests that children whose speech and/or language difficulties are still present at the age of 6, when formal schooling begins, are also at increased risk for reading problems. The majority of children with speech problems in preschool years outgrow those difficulties (Shriberg & Kwiatkoski, 1994). As such, the persistence of the speech and language problems indicates difficulties with phonological processing, which are “critical” at the time when formal schooling and early reading skills are acquired. This reasoning is in line with the Simple View of Reading, which proposes that among the skills required for developing word decoding ability are phoneme awareness and alphabet knowledge.

Raitano et al. (2004) explored relationships between language impairment, persistent SSD (i.e., still evident at age 5-6) and pre-literacy skills in children aged 5-6 with a history of SSD (n = 101) and a control group (n = 41) by assessing performance on PA (a composite of rhyme oddity, phoneme elision, blending and sound matching tasks) and letter knowledge (combined letter name and letter sound knowledge). Primarily, they were interested in knowing the relationship of each possible risk factor (LI and persistent SSD) on the dependent measures, as well as investigating whether those with a history of
SSD whose speech problems had resolved (i.e., “normalized”) and no other risk factor, would have similar deficits or perform more similarly to the control group. The SSD group as a whole had significantly lower scores on PA and letter knowledge tasks than the control group, even when controlling for differences in nonverbal IQ (which was found to be lower for those with SSD) and SES. Both persistent SSD and LI contributed significantly to poor PA scores.

When examining whether SSD without either risk factor of persistence or LI (i.e., those with “normalized SSD”), would still impact performance on pre-literacy measures, Raitano et al. (2004) found that children with normalized SSD still performed less well than the control group on PA scores, but did not find significant differences for letter knowledge. Thus, children with SSD--normalized or persistent, comorbid with LI or not-performed more poorly on PA tasks than the control group, but those with additional risk factors had lower letter knowledge (a composite of letter name, sound and writing), and had the lowest overall scores on all measures.

Peterson, Pennington, Shriberg and Boada (2009) further investigated the idea that children with SSD who are at greatest risk for future reading problems are those who have comorbid language impairments by analyzing longitudinal data from the same participant set as in Raitano et al. (2004), at age 7-9. At this later time point, Peterson et al. asked whether the children with a history of SSD would have poorer literacy outcomes and higher incidences of reading disabilities (RD), whether language status (impaired or not) would better predict RD than SSD persistence, and whether phonological awareness alone predicted literacy outcomes for this sample or whether additional variables (e.g.,
nonverbal IQ) were required for more adequate prediction. It was found that as a group, the children with SSD performed less well on the overall literacy composite score. Specifically, those with SSD had higher rates of RD (22.1%) than the controls (5.4%). However, regression analyses on the speech and language composites determined that each of the four language composites assessed in this study predicted literacy outcomes more strongly than the speech composite and no relationship was found between earlier SSD and later reading outcomes, after language status was accounted for. It is notable, however, that nearly 20% of children whose speech difficulties had normalized nonetheless demonstrated a reading disability.

**Risks to reading in children with SSD: The influence of atypical errors.** Both language impairment and persistent speech problems are likely to impact early reading development, but in attempts to identify those children as early as possible, researchers have considered various ways in which to meaningfully subgroup children with SSD. Although measures of intelligibility using scales such as percentage consonants correct (PCC) (Shriberg, Austin, Lewis, McSweeny & Lewis, 1997), which categorize children’s speech errors as mild, moderate, severe or profound can be useful for classifying children’s errors, some researchers (e.g., Dodd, 1995; Hesketh et al., 2000; Preston & Edwards, 2010) have argued that intelligibility measures will not necessarily predict which children are at risk for concomitant difficulties in language and literacy. For example, Dodd (1995) suggests classifying children according to the types of speech errors produced, and has provided evidence for differences among these subgroups (Dodd, 2005). In this system, children are classified as having an articulation disorder,
or impairments in pronouncing specific phonemes both in isolation and connected speech; *phonological delay*, when children demonstrate error patterns that are seen in younger, typically developing children; *consistent phonological disorder*, for children who use unusual or atypical speech patterns and errors that are not seen in typically developing children; and *inconsistent phonological disorder*, for children who may demonstrate multiple error patterns for the same word or phonological form. Children whose difficulties are phonological in nature, then, are likely to exhibit risk for future reading problems, regardless of the severity of their speech errors, and those with atypical errors may exhibit greatest risk.

In support of this idea, Holm, Farrier & Dodd (2008) investigated which subtypes of children with phonological disorders presented with PA deficits and hypothesized that only those with atypical errors would have these difficulties. Their sample of 62 children, with a mean age of 5;3, was divided into those with “speech delay”, those with consistent, yet atypical errors and those with inconsistent errors. All groups of children performed similarly on measures of receptive vocabulary; however, the speech-disordered children as a group had lower PA skills than typically-developing children, and those exhibiting consistent yet atypical errors had the lowest scores of all groups.

Taken together, these studies suggest that children with SSD and concomitant language difficulties are at risk for later reading difficulties. However, the data collectively also suggest that children whose isolated speech difficulties that are still present at school age, (i.e., 5-6 years) are also at risk due to poor phonological awareness (Anthony et al., 2011; Broomfield & Dodd, 2005; Hesketh et al., 2000; Raitano et al,
Within the SVR framework discussed earlier, a deficit in PA, particularly phoneme awareness, is likely to impact the development of word decoding skills. Although many of the studies noted above are similar in showing a general deficit of PA in children with SSD, it is less clear from these studies which aspects of phonological awareness are poorest. That is, because most studies examining phonological awareness combine scores from various tasks for a composite score, or use a variety of tasks to assess PA, it is unclear whether there are differences between awareness of syllables and rimes from awareness of phonemes, which is shown to be the best indicator of reading ability. The following sections review the studies that have examined levels of PA in children with SSD, as well as studies examining AK.

Levels of PA in children with SSD. Accumulating evidence suggests that many children with SSD have lower composite phonological awareness scores (rhymes, syllables, and phonemes) as compared to typically developing children (Anthony et al., 2011; Larrivee & Catts, 1999; Rvachew et al., 2003; Treiman et al., 2008). Several studies have also found that children with SSD show specific deficits on tasks involving phoneme deletion and segmentation (e.g., Hesketh et al., 2000; Webster & Plante, 1992). However, although previous studies have provided descriptive information on different types of PA tasks for both typically developing children and those with SSD, statistically significant within group differences are rarely reported (Hesketh et al., 2000). For example, Webster and Plante (1992) studied a range of language and literacy abilities in 11 children, between the ages of 6 and 8, with moderate to severe SSD. Although their abilities on receptive language, semantic and pragmatic tests and a syllable identification
task were not significantly different compared to typically developing children, their scores on PA subtests of phoneme identification were significantly poorer than the control group. It can be inferred from these results that children would have poorer scores on phoneme awareness than syllable awareness, though their results did not statistically compare scores from the PA subtests for either the SSD or typically developing group.

Carroll and Snowling (2004) reported similar outcomes in their study of 17 children with isolated speech impairment, between the ages of 4 and 6. On PA subtests of rhyme awareness and initial phoneme matching, the group of children with speech difficulties scored significantly poorer than typically developing children, but performed no differently from the control group on the syllable awareness task. Although between group differences on various PA tasks were assessed, within group differences were not. Thus, whether the children with SSD performed similarly on the rhyme and phoneme tasks was not further investigated.

A study by Hesketh and colleagues (2000) did compare performance on different PA tasks within a group of children with SSD, (those who scores -1SD of the mean on an articulation test and normal receptive language skills), as well as compared to typically developing children. They found differences between groups such that the SSD group had scores in the following order (highest to lowest): phoneme blending, rhyme, onset matching, and word initial phoneme matching (which requires segmentation), and consonant deletion, with scores on word initial matching and consonant deletion being significantly poorer. However, although levels of PA were assessed, the nature of the
tasks also differed. Thus, whether children did more poorly on consonant deletion because of deficits in phoneme awareness or because of the more complex cognitive operation was not clarified.

In sum, numerous studies have found that children with isolated SSD have lower PA skills when compared to typically developing children. Some studies have shown particularly weak performance on phoneme related tasks, in comparison to typically developing children; however, with the exception of one study (Hesketh et al., 2000), within group differences on tasks assessing levels of PA have not been previously reported. Thus, the possible confounds of variable task requirements prevents conclusions about whether children with SSD, with normal language skills, exhibit poor overall phonological awareness, or may have deficits specific to phoneme awareness.

In light of the review of literature provided above, the question of whether or not children with SSD have specific deficits in phoneme awareness is also of interest because of the strong purported correlations between phonemic awareness and AK reported in the literature on typically developing children and the notion that deriving LSK from letter names may be facilitated by phonological segmentation at the level of onsets (for CV letters) and rimes and final phonemes (for VC letters). The important role of alphabet knowledge, as indicated in the Simple View of Reading, has not been as extensively researched in children with SSD. Understanding more about specific phonological deficits in this population, and whether it impacts the development of other, associated early decoding skills may provide important additional information about why some children are at risk for reading difficulties.
**Alphabet knowledge in children with SSD.** Although most studies examining the early literacy development of children with SSD have focused on PA, fewer have assessed alphabet knowledge as well (Anthony et al., 2011; Bird et al., 1995; Carroll & Snowling, 2004; Nathan et al., 2004; Raitano et al., 2004; Rvachew et al., 2003; Treiman et al., 2008). Furthermore, findings from these few studies are mixed. Several studies have reported alphabet knowledge as a composite score of letter name and sound knowledge (Carroll & Snowling, 2004; Nathan et al., 2004; Raitano et al., 2004) and found that children with SSD have significantly poorer scores as compared to typically developing children. Rvachew et al. (2003) examined only letter name knowledge and found that four-year-old children with SSD \((n = 13)\) did not score significantly differently from a group of typically developing children, matched on a measure of receptive vocabulary. Carroll and Snowling (2004), on the other hand, examined only LSK for letters that children knew the names of, and found that their group of children, ages 3.5-6, with speech difficulties \((n = 17)\) had significantly lower scores than typically developing children matched for age and vocabulary.

Of the three studies examining both LNK and LSK separately (Anthony et al., 2011; Bird et al., 1995; Treiman et al., 2008), not all have found that children with SSD had lower scores on both measures compared to children with typical development. Specifically, Anthony and colleagues (2011) found that preschool-aged children with moderate SSD \((n = 68)\) as a group had lower scores on both LNK and LSK than typically developing children, but performed similarly to a group of children matched for language ability with normal speech skills. Thus, the authors concluded that the poorer AK
exhibited in their group of children with SSD was due to their lower language ability and not related to their SSD. Bird et al. (1995), in contrast, found that a group of children, between the ages of 5 and 7, whose expressive speech disorder ranged from mild to severe, had significantly lower scores on LSK than a group of typically developing children. In addition, those researchers found that the subgroup of those children with concomitant speech and language difficulties also had lower scores for letter name knowledge. However, the names and sounds of only 10 letters were assessed, which limits stronger conclusions about the status of alphabet knowledge in their group of participants. Finally, Treiman and colleagues (2008) also examined both LNK and LSK in children ages 5-6, and found significant group differences for both measures between children with \( n = 104 \) and without SSD \( n = 39 \), and particularly for the subgroup of children with concomitant LI \( n = 23 \). The children with SSD represented a heterogeneous group, with some whose SSD had normalized \( n = 65 \) at the time of testing. Although all children (SSD and TD) demonstrated greater knowledge about letter names than sounds, similar to Bird et al.’s (1995) findings, all children with SSD, even those without concomitant language impairment, performed particularly poorly on LSK. Thus, the few studies examining the extent of LNK and LSK in children with SSD have had conflicting results. The children in Anthony et al. (2011) were younger, thus, it is possible that the impacts from a persisting speech disorder on alphabet knowledge would not be evident until a later age. However, since the children in the other two studies (Bird et al., 1995; Treiman et al., 2008) ranged in terms of language ability, and
were not assessed on all letters of the alphabet, a clear understanding of whether children with SSD demonstrate poor or adequate LNK and LSK warrants further investigation.

**Alphabet knowledge by letter categories in children with SSD.** Treiman and colleagues provided additional information about LSK in children with SSD to that obtained by Bird et al. (1995) and Anthony et al. (2011) by further investigating whether children with SSD had better LSK of certain letter name categories than others (i.e., CV, VC, NA). Their results showed that all children (with and without SSD and language impairment) demonstrated identical patterns of LSK such that significant differences were seen between three categories (i.e., CV > VC > NA). Knowledge of vowel sounds was not assessed. However, when examining just the children who had poor PA \(n = 14\), as determined by scoring at chance or below on both rhyme judgment and sound matching, patterns of LSK were remarkably different. For this small subset of children, half of whom had concomitant LI, LSK of CV sounds was greater than all other categories, with no further differences found between VC and NA letters. However, this difference may have been due to floor effects, in that children in that subgroup knew very few of those letter sounds. Thus, although Treiman et al. (2008) provide important information about LSK in children with SSD, their study highlights additional areas that warrant further work. Specifically, because only a subset of letters was evaluated to assess LNK and LSK, information about overall levels of alphabet knowledge in kindergarten aged children with SSD remains incomplete. Furthermore, although differences by letter name category appeared to reflect similar patterns as those seen in
typically developing children, floor effects may have prevented a more comprehensive analysis of those differences.

**Relationships between LSK and PA in children with SSD.** In their 2008 study, Treiman and colleagues reasoned that if phonological awareness were strongly correlated with LSK, then children with deficits in one area, such as those showing poorer PA associated with their SSD, would have poorer skills in the other areas. Additionally, Treiman and colleagues proposed that examining specific correlations between phonological awareness and knowledge of the sounds of letters that included phonological clues in the names (b - /bi/, d - /di/) would provide evidence for this relationship as well. That is, phonological awareness should correlate with knowledge for CV and VC letters, which provide a phonological clue to the associated letter sound, but not correlate with knowledge for the letters with names that do provide such information about its sound (NA letters; e.g. “w”). However, Treiman et al. (2008) found that correlation coefficients between the PA composite scores and the three categories of letter sounds were positive, significant, and very similar in strength. The finding from many previous studies that PA and LSK are strongly related was corroborated, as correlations between PA and each letter name category were significant. However, Treiman et al.’s hypothesis that correlations between PA and NA letters should not be significant because PA is not needed to derive the letter sound of NA letters was not upheld. Thus, they argued that phonological awareness—at least as measured by standardized assessments—was not necessary for developing the pattern of LSK predicted by the name-to-sound facilitation process. Unfortunately, these correlations were
calculated across all groups (typical and SS, with and without LI). Additionally, correlations were between a PA composite score and LSK; thus, no conclusions as to how categories of LSK and varying levels of PA specifically correlate in children with SSD could be drawn from this study, making this yet another area in which our information about children with SSD is incomplete. Finally, their study notes that children with poor PA had particularly low levels of LSK. However, half of the children subgrouped as such had concomitant language impairments. Thus, the nature of these relationships, and the strength of these skills, in children with isolated SSD remains unknown. Because many children with SSD are likely to have poor PA, further investigation into their alphabet knowledge (both LNK and LSK) is essential to better understand their potential areas of specific weakness in word decoding skills.

**Purpose of the present study**

Taken together, the studies discussed above suggest that many children with SSD exhibit poorer phonological awareness than typically developing children, perhaps particularly for tasks requiring phonemic awareness, although whether this is a specific deficit is not clear. Furthermore, although a deficit in phoneme awareness may put children with SSD at risk for reading acquisition, particularly at the age of formal school entrance (Bird et al., 1995; Raitano et al., 2004), the status of their letter name and letter sound knowledge--also critical for reading acquisition--is rarely reported. Previous research is limited in addressing some of these issues because study samples include children with a diverse range of language ability. Therefore, the extent to which these two skills correlate in this specific population remains unknown. Investigating these
issues is important not only for further understanding the range of deficits and strengths exhibited by children with SSD at a critical stage in their academic development but also for a broader understanding of the ways in which phonological awareness and alphabet knowledge are related. Therefore, the proposed study aims to expand on previous work (especially Treiman et al., 2008) by examining the constructs of alphabet knowledge and phonological awareness in children with a primary diagnosis of SSD. Based on the literature reviewed above, it is likely that children with SSD will demonstrate greater levels of knowledge about letter name than letter sounds, and that their knowledge of letter sounds will resemble patterns seen in typically developing children (CV > VC > NA). It is also likely that children will demonstrate differences in their ability to delete larger structures and phonemes in a deletion task. However, given the paucity of literature about these particular skills in kindergarten children with SSD, the following research questions, which address alphabet knowledge, phonological awareness, and their relationships, are largely exploratory:

1) Do kindergarten children with SSD differ in their knowledge of letter sounds (LSK) and letter names (LNK)?

2) Does their knowledge of letter names and sounds differ by letter name categorization reflecting the way in which the letter name encodes the sound associated with the letter (e.g., CV, VC, NA, and vowel)?

3) Do children with SSD exhibit differences in their ability to manipulate phonological structures that differ in size (larger vs. smaller) within an elision task?
4) Is children’s alphabet knowledge (LNK and LSK) related to ability on a elision task (involving the deletion of words, syllables, and single sounds)?
Participants

Participants in the present study were 16 kindergarten children with a primary diagnosis of speech sound disorder (SSD) of unknown etiology. They ranged in age from 68 to 83 months ($M = 72.25, SD = 4.09$), and included 3 girls and 13 boys. Although SSD is reportedly more prevalent in boys than in girls for this age group; the ratio in the present study is nonetheless higher than in some other studies (e.g., Shriberg, Tomblin, & McSweeny, 1999). Levels of maternal education varied within the group, with 6 mothers (37.5%) having completed a college degree or higher, 6 (37.5%) having had partial college training, and 4 (25%) having completed high school or the GED as their highest level of education. In terms of children’s school placements, 6 children attended half-day kindergarten, and 10 attended a full-day program. Whereas 9 children had been receiving speech-language intervention prior to entering kindergarten, 7 began receiving services only after starting kindergarten.

Participants were recruited from a variety of sources. The majority (11 children) had been identified as potentially eligible through a chart review of a local hospital’s speech pathology records of patients who had previously indicated a willingness to be contacted for future relevant research studies. Five other children were recruited through family responses to information provided by community/school speech-language pathologists. These clinicians had been given flyers and other written information about
the inclusionary and consent requirements for the study to distribute to families of eligible children. Interested families returned completed consent forms directly to the research lab.

**Inclusion Criteria**

Children included in this study were required to meet the following criteria (full detail of these assessments is provided subsequently):

1. Primary diagnosis of SSD of unknown origin (i.e., diagnosis not associated with a known organic cause such as Down Syndrome, cerebral palsy, cleft palate, etc.).
2. Score at or below the 16th percentile on the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 2000) and evidence of three or more types of phonological process errors identified by the Khan-Lewis Phonological Analysis – 2nd edition (KLPA-2; Khan & Lewis, 2002).
3. English as the primary language spoken in the child’s home, as reported by the child’s parent and verified informally at an initial screening.
5. Score no less than 1 SD below the mean on the Core Language composite of the Clinical Evaluation of Language Fundamentals-4 (CELF-4, Semel, Wiig & Secord, 2003).
6. Normal hearing and cognitive function, as reported by the child’s parent. Specifically, parents were asked to describe their child’s history of hearing by indicating if their child had cochlear implants, had a history of middle ear
infections (including how many and the most recent date of doctor’s visit for this problem), or had no history of ear infections and normal hearing. To provide information about the presence of any concomitant difficulties, parents were asked to indicate whether their child had a diagnosis, or suspected diagnosis of cerebral palsy, developmental apraxia, cognitive impairment or delay or intellectual disability, autism spectrum disorder, head injury, or a genetic syndrome (i.e., Down syndrome, Fragile X, Williams syndrome).

7. Normal oral-motor function, as verified by scoring at or above the criterion score for their age on the Oral Motor Screen of the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Hua, Crosbie, Holm & Ozanne, 2009).

**Study Procedures**

**Pre-Screening.** When families contacted the researcher, either by phone, email or by returning the consent forms, pre-screening information was obtained to determine general eligibility. Parents were asked whether the child had any history of hearing loss, whether their child’s SSD was secondary to another disorder or disability, specifically cleft palate, hearing loss, cerebral palsy, head injury or a genetic syndrome, and whether English was the primary language spoken in the home. Parents also confirmed that the child was currently attending a kindergarten program, either at a public or private institution. After the general procedures and aims of the study were explained, families interested in participating scheduled a testing time at their desired location.
A total of 30 potential participants responded to mailings \((n = 21)\), were referred by their SLP \((n = 5)\) or contacted the researcher to participate in this study \((n = 4)\). Through the pre-screening process, 9 children were deemed ineligible, either because they were too young \((n = 3)\), or had other diagnoses such as autism spectrum disorder \((n = 2)\), cognitive impairment \((n = 1)\), or hearing problems \((n = 3)\).

**Part 1. Screening.** Several screening and eligibility measures were obtained to confirm eligibility of children whose parents returned consent forms. This testing took place either at the child’s school or at the Children’s Communication Laboratory at The Ohio State University, depending on the preference of the parent. The five measures consisted of a parent questionnaire, articulation assessment, language testing, a language/dialect variation screening, and an oral motor screening, randomly ordered for each participant. The standardized assessments for articulation, language and oral motor screening were administered by the author according to the manual’s instructions (details of each assessment procedure are provided below). All children had standard scores on the CELF-4 (Semel, et al., 2003) that were within 1 SD of the mean and exhibited normal oral motor skills. Results from the DELV (Seymour, Roeper, & deVilliers, 2003) screening revealed that 3 of the 16 children spoke a dialect other than Standard American English, but not did not exhibit risk for language impairment. Although all children demonstrated at least three different phonological processes, as required for eligibility in this study, scores on the GFTA-2 ranged within this group. Descriptive information about the participants’ articulation and language skills is provided in Table 1.
Table 1

Mean standard scores standardized assessments of children with SSD (n=16)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean (standard deviation)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>CELF-4 Core Language – standard score</td>
<td>107.8 (9.15)</td>
<td>93-118</td>
</tr>
<tr>
<td>GFTA-2 standard score</td>
<td>78.15 (9.06)</td>
<td>57-85</td>
</tr>
</tbody>
</table>


**Parent Questionnaire.** Parents who returned the consent form also completed a short questionnaire that gathered demographic and health history information on participating children (see Appendix A). Additionally, mothers/primary caregivers were asked to indicate the highest level of education they had attained for use as an indicator of socioeconomic status (Dollaghan et al., 1999).

**Diagnostic Evaluation of Articulation and Phonology.** Normal oral motor function was assessed with the Oral Motor Screen of the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Hua, Crosbie, Holm & Ozanne, 2009). This screening requires children’s completion of a diadochokinetic task (repeating “pat-a-cake”), imitation of four isolated oral motor movements (e.g., “put your tongue up to the top of your lip, like this”) and imitation of three different sequenced movements (e.g., “Blow and then put your tongue up, like this”). The screening takes approximately 5 minutes to administer, and is suitable for children ages 3 to 8 years. Eligibility for the present study required that children achieve at or above the criterion score for their age.
range (49-52 for children age 5;6 to 6;11). For the Oral Motor Screen for this age group, the test manual indicates an acceptably high test-retest reliability \( (r = .81) \) and similarly acceptable internal consistency (Cronbach’s coefficient alpha = 0.84-0.87).

**Language – Clinical Evaluations of Language Fundamentals-4 (Semel et al., 2003).** In order to address the research questions that specifically pertained to children with isolated SSD, it was necessary to ensure they had language abilities within normal limits. Expressive and receptive language was assessed using the Core Language composite of the CELF-4, (Semel, et al., 2003), which incorporates results from 4 subtests: Concepts and Following Directions, Word Structure, Recalling Sentences and Formulated Sentences. In the Concepts and Following Directions subtest, children are either instructed to point to pictures in a specific order (e.g., “First point to the ball, and then to the fish. Go”) or to pictures that represent a specific concept (“Point to the biggest apple. Go”). In Word Structure, children must complete sentences using target structures represented through illustrations. This subtest is an expressive task assessing the child’s knowledge of grammatical rules. In the Recalling Sentences subtest, children are asked to repeat a sentence presented by the examiner. The sentences vary in length and complexity. In the Formulated Sentences subtest, children are presented with an illustration and asked to create a sentence using target words or phrases. The sentences vary in length and complexity. The Core Language subtests require approximately 30 to 45 minutes to administer, and measures general language ability of children between the ages of 5 and 21. Standard scores are calculated and combined to yield a composite score. Eligibility for the present study required that children score no lower than -1.33 SD.
from the mean; however, all participants scored within 1 SD of the mean. The test manual indicates that test-retest reliability coefficients for the subtests ranged from .71-.86. Internal consistency was measured using Cronbach’s coefficient alpha with reported subtests values from .69 to .91 and using split-half reliability, with reported subtest values from .71 to .92.

Language variation—The Diagnostic Evaluation of Language Variation—Screening Test (Seymour et al., 2003). In order to distinguish children who exhibit risk for language impairment from those whose American English dialects may vary, the Diagnostic Evaluation of Language Variation—Screening Test (DELV, Seymour, et al., 2003) was administered. This screening is used for children between the ages of 4 and 12 and can be administered in 15-20 minutes. Although the test manual notes that further reliability testing is required, the current test-retest reliability ($r = .80$) was acceptable for the purposes of this study.

Speech Sound Production—The Goldman-Fristoe Test of Articulation-2. Speech sound production was assessed using the Sounds-in-Words subtest of the Goldman-Fristoe Test of Articulation-2 (GFTA-2, Goldman & Fristoe, 2000), which is commonly used in both research and clinical settings to measure a child’s articulation skills and can be used for students between the ages of 2-21. For this assessment, children are shown pictures, and asked to identify the objects seen in the pages. A total of 53 single words are elicited, and include 77 consonants or consonant clusters in varying positions (initial, medial, and final). Standard scores are calculated according to gender and age range; eligibility for the present study required that children’s standard scores fall at or below
the 16th percentile ranking, indicating performance below that expected for children of their age and gender. According to the manual, the median test-retest reliability for phonemes in the initial, medial, and final positions of words is excellent ($r = .98$). Median percentages of inter-rater agreement on consonant scorings are 93% in syllable initial position, and 90% in the medial and final positions. Participants’ GFTA-2 results were further analyzed to look at expressive phonology with the Khan Lewis Phonological Analysis 2nd edition (KLPA-2, Khan & Lewis, 2002). This tool allows the responses to be additionally assessed in terms of phonological processes. Eligibility for the present study required that children demonstrate at least three different processes (e.g., fronting, final consonant deletion).

Of the 21 children who were scheduled to participate in the screening assessments, 3 were unable to complete the testing protocol, and 2 had GFTA standard scores above the 16th percentile. Thus, 16 kindergarten children with SSD were included in the study and completed the alphabet knowledge and phonological awareness assessments described below.

**Part 2. Experimental measures.** Children who met the eligibility criteria above were examined in a second session for the experimental measures. This testing session occurred either at the child’s school or the Children’s Communication Laboratory, according to parent preference. All measures were administered by the author; children’s verbal responses were audio recorded in order to ensure correct scoring for any responses that were difficult to understand.

*Alphabet knowledge – Production of letter names and letter sounds.* Similar to
previous studies assessing alphabet knowledge (e.g., Carroll, 2004; Piasta & Wagner, 2010; Treiman et al., 2008), flashcards were used to assess lowercase letter names (LNK) and letter sounds (LSK).

To assess LNK, children were shown each of the 26 letters in lower case form, on individual cards and in fixed random order for each child. The researcher introduced the task by saying, “Now we’re going to talk about the names of letters in the alphabet. I’m going to show you a letter, and I’d like you to tell me the name of it.” Responses were coded as either “1” for correct or “0” for incorrect. Cronbach’s alpha within the current sample for LNK was very low (.117), undoubtedly reflecting the ceiling effect for this task within this group. If a child responded with either the sound or a word that started with that letter, the researcher redirected the child to the task and asked, “Can you tell me the name of this letter?”

To assess LSK, children were shown each of the 26 letters in lower case form, on individual cards and in fixed random order for each child. The researcher introduced the task by saying, “Now we’re going to talk about the sounds that the letters in the alphabet. I’m going to show you a letter, and I’d like you to tell me what sound it makes”. If a child responded with either the name or a word that starts with that letter, the researcher re-directed the child to the task and said, “That’s the name of the letter. Can you tell me the sound this letter makes?”

Responses were coded as either “1” for correct or “0” for incorrect. Internal consistency within the current sample was acceptable on this task (Cronbach’s alpha = .80). Phonetic transcriptions of the incorrect responses were recorded. For both letter
name and letter sound assessments, the maximum score was 26. Letters were categorized as CV (consonant-vowel), VC (vowel-consonant), NA (no association) or vowel following procedures in previous studies (e.g., Evans et al., 2006; Piasta & Wagner, 2010; Treiman et al., 1998). As in other studies assessing LSK (Evans et al., 2006; Treiman & Broderick, 1998; Treiman et al., 2008), both long and short vowel sounds were accepted as correct, but children were asked to produce both. Long vowel sounds correspond to a CV category, and short sounds correspond to the NA category. For the consonants c, g, and x, both “hard” and “soft” sounds were accepted (c - /s/ and /k/; g - /g/ and /ʤ/; x - /ks/ and /z/). The percentage correct for each of the four letter categories (i.e., CV, VC, NA, and vowel) for both letter name and letter sound knowledge was then calculated for each participant. Table 2 shows the categorization for each letter.

Table 2

Letter name categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Letters included</th>
<th>Description of letter sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>consonant vowel (CV)</td>
<td>b, d, j, k, p, t, v, z</td>
<td>Consonant + /i/ or /e/</td>
</tr>
<tr>
<td>vowel consonant (VC)</td>
<td>f, l, m, n, r, s, x</td>
<td>/e/ + Consonant</td>
</tr>
<tr>
<td>no association (NA)</td>
<td>c, g, h, q, w, y</td>
<td>No direct relationship between letter name and letter sound</td>
</tr>
<tr>
<td>vowel (V)</td>
<td>a, e, i, o, u</td>
<td>Long sound corresponds with letter name; short vowel sounds do not</td>
</tr>
</tbody>
</table>

Alphabet knowledge—Recognition of letter names and letter sounds. After the alphabet knowledge production tasks, children were assessed on their ability to recognize
letters of the alphabet. Although letter recognition is a skill that has been shown to be
distinct from and precede letter production in typically developing children (Dodd &
Carr, 2003), it was anticipated that the articulation difficulties of the children in this study
might interfere with their ability to display their knowledge of letter names and sounds.
Thus, the inclusion of this additional task provided another chance to gather information
about the extent of their alphabet knowledge.

For both letter name and letter sound recognition, a large laminated sheet of paper
containing all 26 letters was shown to the children. For the letter name recognition task,
children were instructed to listen to the letter name pronounced by the researcher, then
point to the appropriate letter. To begin, the researcher said, “Now I’m going to show
you all the letters of the alphabet. This time I’ll tell you the name of the letter, and I’d
like you to point to it. Can you point to the letter ‘b’?” If children were hesitant or
initially respond with “I don’t know”, verbal encouragement to try to respond was
offered. Following methods in Dodd and Carr (2003), if the children did not respond in 5
seconds, the examiner marked that letter as “0” for incorrect and moved on the next
letter. The order of letter names presented to children was random and different for each
child.

For the letter sound recognition task, children were instructed to listen to the letter
sound pronounced by the researcher, then point to the appropriate letter. To begin, the
examiner said “You did a great job with that! This time, I’m going to tell you a sound
that a letter makes, and I’d like you to point to that letter. Can you point to the letter that
makes the /bʌ/ sound? Similar to procedures listed above, if children were hesitant or
initially responded with “I don’t know”, verbal encouragement to try to respond was offered. Following methods used in Dodd and Carr (2003), if children did respond in 5 seconds, the examiner marked that letter as “0” for incorrect, and move on the next letter. The order of letter sounds presented to children was random and different for each child.

Production and recognition responses were then compared for each child. If a child did not respond correctly for the production task, but answered correctly for the recognition task for any given letter, they were given a score of .5 for that letter. Despite the inclusion of this task to account for speech sound errors, only one child exhibited different scores for two letters on the alphabet production and recognition tasks, resulting in a total difference score of 1 extra error point in both his LNK and LSK total.

**Phonological awareness.** Phonological awareness was measured by the ability to delete different-sized phonological structures and create and produce new words. This task was chosen because this kind of deletion task for children in kindergarten is a strong predictor of later reading ability (Catts, Fey, Zhang, & Tomblin, 2001; Torgesen, Wagner & Rashotte, 1994). Performance on this task has also been shown to correlate with LSK in typically developing children (deJong, 2007; Foy & Mann, 2006). The test items vary in the size of the deleted unit, such that the first 13 items require deletion of either words or syllables (larger phonological units), and the following 8 items require phoneme deletion (smaller phonological unit). Consequently, this task promotes accurate and efficient measurement of a child’s ability to manipulate phonological units of varying size.
Three training items were administered for which pictures were provided to aid in the completion of the task, as provided in the test instructions (see Appendix B). Children were instructed to delete either a syllable or a phoneme of a word, and produce the word resulting from this deletion. (For example: “Say ‘cupcake.’ Now say ‘cupcake’ without ‘cup’”). For training items, feedback was provided as to whether the child’s responses were correct or incorrect. If incorrect, the researcher would re-prompt, and model the correct response. If correct, the researcher moved on to the next training item. The training items were administered repeatedly until the researcher felt sure that the child understood the task. Although the training items had visual cues, the test items did not; thus children were instructed to listen carefully. Children could ask for items to be repeated, if desired. The instructions provided for this task (Catts et al., 2001) are to discontinue testing after six consecutive errors; however, all items were administered in the present study, in order to assess whether children with SSD would exhibit differences on their ability to delete larger versus smaller phonological structures. Responses were coded as “0” for incorrect and “1” for correct (Cronbach’s alpha for current sample = .82).

**Testing procedure.** Assessments occurred in one or two testing sessions, as described above. Screening assessments (i.e., CELF-4, GFTA-2, oral motor screen, DELV) were administered in random order. Administration of experimental measures was counterbalanced between the two skills (phonological awareness, alphabet knowledge). Short breaks, verbal encouragement (e.g., “You’re doing a great job!,” “I like how hard you’re working today!”) and stickers were offered periodically to children
as incentives to complete the testing protocol. Children who were hesitant at first, or initially responded with “I don’t know,” were encouraged with comments such as “Just give it your best try!” Direct feedback on responses was not offered (except as designated for training items on the deletion task). Total testing time ranged from 60-90 minutes.

Tests eliciting verbal responses were audio recorded using an Olympus DS-40 digital stereo voice recorder. Testing of all children occurred within a relatively short window of time (5 weeks) in order to eliminate confounds of curricular effects that may have been present if some children were tested at varied time points throughout the school year.

Reliability

Inter-judge agreement was assessed for the experimental variables (alphabet knowledge production and phonological awareness). A trained research assistant listened to audio recordings of each child’s responses to all 21 items of the Catts deletion task, and scored responses as correct or incorrect. Percent agreement for the items that could be scored was 95.6% (the audio file for one child’s test was of poor quality and only 13 items could be properly assessed). For measures of alphabet knowledge, inter-judge agreement involved double scoring the results for both LNK and LSK for all participants. This included re-calculating the total correct for LNK and LSK for each participant, as well as total correct for each of the four categories of LNK and LSK for all participants. Percent agreement was as follows: 95.1% for LNK total; 94.3% for LSK total; 100% for LNK-CV; 99.1% for LNK-VC; 97.9% for LNK-NA; 100% for LNK-Vowel; 95.2% for LSK-CV; 96.4% for LSK-VC; 95.8% for LSK-NA; 100% for LSK-Vowel.
Data Analysis

The present study asked four research questions centered on the status of alphabet knowledge (LNK and LSK) and phonological awareness in kindergarten children with SSD. SPSS version 19.0 was used to run analyses. The analytical techniques used to address the proposed research questions are described below; an alpha level of .05 was used for all analyses:

**Question 1.** Do kindergarten children with SSD differ in their knowledge of letter sounds (LSK) and letter names (LNK)? To address this research question, I used a paired t-test to compare children’s mean percentage correct scores on these two tasks.

**Question 2.** Does their knowledge of letter names and sounds differ by letter name categorization reflecting the way in which the letter name encodes the sound associated with the letter (e.g., CV, VC, NA, and vowel)? To address this research question, a repeated measures ANOVA was used, with letter category as the within participant measure, and percentage correct as the dependent variable.

**Question 3.** Do children with SSD perform differently on two parts of a phonological elision task, in which the size of the deleted structure varies (words and syllables versus phonemes)? To address this question, a paired t-test examined differences in percentage obtained scores when children were asked to delete larger structures (words and syllables) versus smaller structures (phonemes).

**Question 4.** Is children’s accuracy on LNK and LSK related to their accuracy on the elision task? To address this question, Pearson Product Moment Correlations were calculated using mean percentage correct scores from LNK, LSK and PA. Recent studies
(e.g., Kim et al., 2010; Piasta & Wagner, 2010) have evaluated how PA contributes to children’s alphabet knowledge by using cross-classified multilevel models (CCMLMs), which allow for the partitioning of variance among students and among letter name categories. In such studies, the research questions focus on predicting the probabilities of children’s letter sound knowledge as a function of their knowledge about letter names and/or their phonological awareness. The purpose of the present study, however, was to examine mean differences between letter name categories in a single group of children with SSD and address basic questions about the relationships between alphabet knowledge and phonological awareness. In doing so, the present study aimed to extend findings of the only previous study that has examined these two variables in this specific population (Treiman et al., 2008); thus, a similar analytical approach was used to facilitate the comparison of outcomes. Future analyses will further develop the current project findings by utilizing a multi-level model.
Chapter 4: Results

The primary purpose of the present study was to examine the status of two individual word decoding skills—alphabet knowledge and phonological awareness—in kindergarten children with SSD. Alphabet knowledge was investigated in two ways: first, to determine if children exhibited differences in their levels of letter name and letter sound knowledge, and second to determine if they exhibited differences in alphabet knowledge as a function of four separate letter name categories. Determining whether children with SSD showed differences in their levels of phonological awareness was also of interest, as it has been shown that phoneme awareness is a significant predictor of word reading ability (e.g., Catts, 1993, Nation & Hulme, 1997). The final aim of the study was to examine relations between both aspects of alphabet knowledge (LNK and LSK) and phonological awareness to explore how these skills correlate in this population. Eighteen children with SSD, between the ages of 5;6 to 6;11, were assessed in order to determine eligibility for participation in the study. Data from the sixteen children who met the inclusion criteria were analyzed to address the study’s research questions and are presented below. Descriptive information for the mean scores of each of the experimental variables is shown in Table 3.
Table 3
Descriptive statistics for alphabet knowledge and phonological awareness

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean raw score (standard deviation)</th>
<th>Raw score range</th>
<th>Mean % correct (standard deviation)</th>
<th>Mean % correct range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNK total (n = 26)</td>
<td>24.88 (1.08)</td>
<td>22-26</td>
<td>95.9 (4.33)</td>
<td>84.6-100</td>
</tr>
<tr>
<td>LNK – CV (n = 8)</td>
<td>7.25 (1)</td>
<td>5-8</td>
<td>92.5 (10)</td>
<td>62.5-100</td>
</tr>
<tr>
<td>LNK – VC (n = 7)</td>
<td>6.75 (.45)</td>
<td>6-7</td>
<td>95.83 (7.47)</td>
<td>83.3-100</td>
</tr>
<tr>
<td>LNK – NA (n = 6)</td>
<td>5.63 (1.02)</td>
<td>2-6</td>
<td>92.5 (20.49)</td>
<td>33.3-100</td>
</tr>
<tr>
<td>LNK – vowel (n = 5)</td>
<td>5 (0)</td>
<td>--</td>
<td>100 (0)</td>
<td>--</td>
</tr>
<tr>
<td>LSK total (n = 26)</td>
<td>22.75 (2.69)</td>
<td>19-26</td>
<td>86.79 (12.02)</td>
<td>58.06-100</td>
</tr>
<tr>
<td>LSK – CV (n = 8)</td>
<td>7.25 (1)</td>
<td>6-8</td>
<td>90.94 (12.14)</td>
<td>75-100</td>
</tr>
<tr>
<td>LSK – VC (n = 7)</td>
<td>6.25 (.85)</td>
<td>4-7</td>
<td>89.38 (12.26)</td>
<td>57.14-100</td>
</tr>
<tr>
<td>LSK – NA (n = 6)</td>
<td>4.68 (1.01)</td>
<td>3-6</td>
<td>78.11 (16.67)</td>
<td>50-100</td>
</tr>
<tr>
<td>LSK – vowel (n = 5)</td>
<td>4.25 (.68)</td>
<td>3-5</td>
<td>85 (13.66)</td>
<td>60-100</td>
</tr>
<tr>
<td>Catts – word (n = 5)</td>
<td>3.81 (1.47)</td>
<td>0-5</td>
<td>76.25 (29.41)</td>
<td>0-100</td>
</tr>
<tr>
<td>Catts – syllable (n = 8)</td>
<td>5.06 (2.46)</td>
<td>1-8</td>
<td>63.59 (30.93)</td>
<td>12.5-100</td>
</tr>
<tr>
<td>Catts – larger (n = 13)</td>
<td>8.94 (3.57)</td>
<td>3-13</td>
<td>68.73 (27.45)</td>
<td>23.07-100</td>
</tr>
<tr>
<td>Catts – phoneme (n = 8)</td>
<td>3.69 (3.57)</td>
<td>0-7</td>
<td>46.41 (31.19)</td>
<td>0-87.5</td>
</tr>
<tr>
<td>Catts total (n = 21)</td>
<td>12.56 (5.25)</td>
<td>4-21</td>
<td>59.81 (25.01)</td>
<td>19.05 – 95.23</td>
</tr>
</tbody>
</table>

Note. LNK = letter name knowledge, CV = consonant-vowel letter names; VC = vowel-consonant letter names, NA = no association letter names, LSK = letter sound knowledge, Catts = Catts deletion task (Catts et al., 2001).
Preliminary examination of the experimental data

The Shapiro-Wilk test, which is appropriate for testing the normality of distributions in small sample sizes (Royston, 1992), was used to assess whether the data violated assumptions of normality. Results showed that the data from the variables on interest in this study did not meet those assumptions (see appendix C). Transformations on the data did not improve the distributions and assumptions of normality were still not met. Although t-tests, which were the primary statistic used in the analyses below, are robust to nonnormal distributions (Lomax, 2007), nonparametric analyses were used to examine the data. However, because the parametric and nonparametric tests yielded the same results in terms of significance (see appendix D for results from nonparametric analyses), the analyses from parametric tests are reported below, for ease of reporting effect size estimates, and should be interpreted with caution.

Alphabet Knowledge in Children with SSD

The first research question of the present study was intended to broadly examine the construct of alphabet knowledge in kindergarten children with SSD, and specifically to determine the extent to which their knowledge of letter names differed from their knowledge of letter sounds. These participants demonstrated greater knowledge of letter names \((M = 24.88, SD = 1.09)\) than of letter sounds \((M = 22.75, SD = 2.69)\). A paired samples t-test determined that this difference was statistically significant; \(t(15) = 3.641, p = .002\). The calculation for Cohen’s \(d (.744)\) indicated a medium to large effect size.

Alphabet knowledge across letter name categories

55
The second research question examined categories of alphabet knowledge in greater detail. First, accuracy on LNK across letter name categories (consonant-vowel, vowel-consonant, not associated, and vowel) was investigated. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean percent correct for LNK was not significantly different across letter name categories ($F(1.547, 23.2) = 1.449, p = .252, \eta^2 = .088$).

Next, accuracy on LSK across letter name categories was investigated. Mauchly’s test indicated that the assumption of sphericity for LSK scores had not been violated ($\chi^2(5) = 5.413, p = .368$). A repeated measures ANOVA with sphericity assumed determined that mean percent correct on LSK was significantly different across letter name categories ($F(3, 45) = 5.263, p = .003, \eta^2 = .26$). Post hoc tests using the Bonferroni correction revealed that only LSK of NA letters was significantly poorer than LSK of CV ($p = .01$). There were no differences between LSK for CV and VC letters ($p = 1.00$), and knowledge of vowel sounds did not differ significantly from LSK of CV ($p = .665$) or NA letters ($p = .243$). Similarly, LSK of VC letters did not differ from LSK of vowels ($p = 1.00$) or NA letters ($p = .113$). LSK of vowels was further explored to determine whether children could demonstrate knowledge of both types of vowel sounds (short and long). Although either short vowel sounds (e.g., /æ/) or long vowel sounds (e.g., /ai/) was accepted as correct, children were asked if they knew both. Children exhibited greater knowledge of short vowel sounds ($M = 83.75, SD = 13.1$) as compared to long vowel sounds ($M = 16.25, SD = 26.55$); a paired samples t-test confirmed this difference to be significant; $t(15) = 9.586, p < .001, d = 2.239$. 

56
The third research question of the present study investigated levels of phonological awareness; specifically, to determine whether children with SSD exhibited differences in their ability to manipulate phonological structures of varying sizes. A phonological elision task was administered that included items requiring the deletion of words, syllables, and phonemes. As such, the mental operation needed to perform this task remained constant, and only the size of the phonological unit was manipulated. Children’s responses were compared for larger structure items (words and syllables) versus smaller structures (phonemes) in terms of percentage correct performance.

Figure 1. Mean percent correct and standard error for LSK across four letter name categories.

Phonological Awareness in Children with SSD

The third research question of the present study investigated levels of phonological awareness; specifically, to determine whether children with SSD exhibited differences in their ability to manipulate phonological structures of varying sizes. A phonological elision task was administered that included items requiring the deletion of words, syllables, and phonemes. As such, the mental operation needed to perform this task remained constant, and only the size of the phonological unit was manipulated. Children’s responses were compared for larger structure items (words and syllables) versus smaller structures (phonemes) in terms of percentage correct performance.
The group of children with SSD in this study exhibited a higher accuracy rate for manipulating larger phonological structures ($M = 68.73, SD = 27.45$) as compared to smaller structures ($M = 46.4, SD = 31.19$). A paired samples t-test confirmed that this difference was statistically significant $t(15) = 3.082, p = .008$. The calculation for Cohen’s $d$ indicated a moderate to large effect size ($d = .76$). Figure 3 depicts the differences seen for items requiring word, syllable and phoneme deletion. Children performed best on word deletion, followed by syllable deletion, and most poorly on phoneme deletion. A repeated measures ANOVA revealed that the only significant differences across these structures were between word-level and phoneme-level items ($F(2, 30) = 8.130, p = .002, \eta^2 = .351$).

![Figure 3](image)

**Figure 2.** Mean percent correct and standard error for items of the Catts deletion task.

**Post hoc examination of the relationship between PA and children’s SSD characteristics.** Although the mean scores for items on the phonological elision task
revealed differences in ability to manipulate larger and smaller structures, there was considerable within-group variability for both larger structures and phonemes. To explore this variability in greater detail, it was of interest to know whether these differences could be explained by either the number or type of speech errors. Specifically, the distribution of GFTA-2 scores revealed a natural subgrouping according to the number of speech errors such that several children had scores that clustered close to the 16th percentile cutoff, and the rest of the scores fell at 10th percentile or below. In order to determine if children with the larger number of speech errors differed in their phoneme awareness than those with fewer errors, the children whose GFTA-2 standard scores fell below 80 were subgrouped into a low-GFTA group (n = 7), and compared with those who had higher scores (n = 9). Figure 3 depicts the mean differences between these subgroups. A one-way ANOVA was used to determine whether the subgroups differed in their accuracy on the deletion of larger structures and phonemes (see Figure 4). Results showed that the subgroups did not differ significantly for deletion of larger structures (F(1,14) = 1.940, p = .185, d = .35) or phonemes (F(1,14) = .589, p = .456, d = .41).

Next, subgroups were created on a post hoc basis with consideration of the type of phonological processes they exhibited, as assessed by the KLPA-2. Children who exhibited processes that usually are eliminated by age 3;0 in typically developing children, including final consonant deletion, velar fronting, and initial voicing (Stoel-Gammon and Dunn, 1985) or processes considered atypical at any age, such as backing to velars (Preston & Edwards, 2010) were subgrouped (n = 6) and compared to those
exhibiting processes that were minimally delayed \((n = 10)\) on the items requiring phoneme deletion (see Appendix E for complete list and description of errors and subgroup placement). This grouping was explored because the former group could be argued to exhibit a more severe SSD than the latter. A one-way ANOVA showed that the group with atypical or more delayed processes \((M = 47.42, SD = 23.03)\) had significantly poorer percentage correct scores on the larger structure deletion items \((M = 81.52, SD = 21.83)\) \((F(1, 14) = 8.801, p = .01, d = 1.51)\). The group with atypical or more delayed processes had significantly poorer percentage correct scores on the phoneme deletion items \((M = 14.58, SD = 20.03)\) than those with minimally delayed errors \((M = 65, SD = 17.48)\), \((F(1, 14) = 28.06, p < .001, d = .285)\) (see Figure 4). Despite these differences between the subgroups on the phonological awareness task, subgroups did not differ significantly on any other of the variables of interest (LNK and LSK across CV, VC, NA and vowel categories).
Figure 3. Mean percent correct and standard error on Catts deletion task (larger vs. smaller structures) by children scoring GFTA standard scores above 80 ($n = 9$) and those with GFTA standard scores below 80 ($n = 7$).
Relationships between Alphabet Knowledge and Phonological Awareness

The relationships between LNK, LSK, and phonological awareness were investigated using Pearson product-moment correlation coefficients. Table 4 provides the coefficients for the relationships between the primary variables of interest (LNK, LSK, Catts deletion task), as well as between those measures and relevant descriptive variables (e.g., age, GFTA-2, and KLPA-2). It was found that children’s speech abilities, measured by the number of speech errors as well as the number of phonological processes exhibited, was moderately correlated with age. In other words, older children
in this study had poorer speech skills compared to younger children. Scores from the GFTA-2 and KLPA-2 were very strongly and positively correlated with each other, which was expected, and that correlation \((r = .92)\) corresponds to the correlations reported in the KLPA-2 manual \((r = .89\) for females, \(r = .88\) for males) (Khan & Lewis, 2002). The speech measures were inversely and moderately correlated with phonological awareness of larger structures, and the KLPA-2 scores were significantly inversely correlated with LSK, suggesting that children demonstrating a greater number of phonological processes had poorer knowledge about letter sounds and more difficulty with the phonological awareness task. Finally, although children’s knowledge about letter names was negatively and weakly correlated to phonological awareness, their knowledge about letter sounds was more strongly related to their performance on the phonological awareness task.
Table 4

*Pearson correlation coefficients between descriptive variables, alphabet knowledge and phonological awareness*

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age in months</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. GFTA-2</td>
<td>.259</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. KLPA-2</td>
<td>.342</td>
<td>.920**</td>
<td>-</td>
<td></td>
<td></td>
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<tr>
<td>4. LNK</td>
<td>.202</td>
<td>-.212</td>
<td>-.153</td>
<td>-</td>
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<tr>
<td>5. LSK</td>
<td>.151</td>
<td>-.366</td>
<td>-.422</td>
<td>.708**</td>
<td>-</td>
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<td></td>
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<tr>
<td>6. Catts total</td>
<td>.086</td>
<td>-.293</td>
<td>-.359</td>
<td>-.209</td>
<td>.378</td>
<td>-</td>
<td></td>
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<tr>
<td>7. Catts-large</td>
<td>-.017</td>
<td>-.386</td>
<td>-.468</td>
<td>-.225</td>
<td>.289</td>
<td>.891**</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8. Catts-phoneme</td>
<td>.167</td>
<td>-.092</td>
<td>-.146</td>
<td>-.164</td>
<td>.378</td>
<td>.832**</td>
<td>.497</td>
<td>-</td>
</tr>
</tbody>
</table>


*p* < .01.

**p* < .001.

Relationships between categories of alphabet knowledge and levels of phonological awareness. The correlation matrix in Table 5 displays the coefficients between the four categories of LNK and LSK and the two levels of phonological awareness (for larger structures and for phonemes), and shows that the only significant
relationships were within the skill areas such that categories of LSK such that knowledge of CV and VC letter sounds were positively correlated, as was LSK of NA letters and vowels, and LSK of VC letters and vowels. Relationships between these specific aspects of the two decoding skills were generally weak, although correlations between both aspects of phonological awareness to LSK of CV letters were largest among all the interrelationships. Specifically, phoneme awareness and LSK of CV letters were moderate to strong ($r = .368$), showing that the children who performed better on the phoneme awareness items demonstrated greater knowledge about the CV letter sounds.
Table 5

Pearson correlation coefficients between levels of phonological awareness and categories of alphabet knowledge

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
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<tr>
<td>1. Catts</td>
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<tr>
<td>3. LSK-CV</td>
<td>.227</td>
<td>.368</td>
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<tr>
<td>4. LSK-VC</td>
<td>.117</td>
<td>-.058</td>
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<td>5. LSK-NA</td>
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<td>.230</td>
<td>.430</td>
<td>.242</td>
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<tr>
<td>6. LSK-NA</td>
<td>-.065</td>
<td>.142</td>
<td>.488</td>
<td>.569*</td>
<td>.688**</td>
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<td>vowel</td>
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<tr>
<td>7. LNK-CV</td>
<td>-.210</td>
<td>.007</td>
<td>.733**</td>
<td>.389</td>
<td>-.157</td>
<td>.488</td>
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<tr>
<td>8. LNK-VC</td>
<td>-.261</td>
<td>.317</td>
<td>.149</td>
<td>.359</td>
<td>.002</td>
<td>.218</td>
<td>.148</td>
<td></td>
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<tr>
<td>9. LNK-NA</td>
<td>.212</td>
<td>.346</td>
<td>.228</td>
<td>.299</td>
<td>.464</td>
<td>.048</td>
<td>.228</td>
<td>-.218</td>
<td></td>
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<tr>
<td>10. LNK-</td>
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</table>

Note. Catts = Catts deletion task (Catts et al., 2001), LNK = letter name knowledge, LSK = letter sound knowledge, CV = consonant-vowel letter names; VC = vowel-consonant letter names, NA = no association letter names.

*p < .01.

**p < .001.
Chapter 5: Discussion

The present study examined alphabet knowledge and phonological awareness skills in kindergarten children with isolated SSD. This study is of interest because of a large body of work on typically developing children suggesting that both of these skills make significant contributions to early word decoding ability, and because of a growing literature base suggesting that children with SSD may have challenges developing these skills. To date, research investigating alphabet knowledge and phonological awareness in children with SSD has focused primarily on children whose phonological disorders are concomitant with language impairment, and on children who are preschool-aged, and has compared children with SSD to typically developing children. Thus, within-group differences on the individual aspects of alphabet knowledge and phonological awareness have not been addressed in the current literature. This study was thus designed to explore these two essential early decoding skills in children with SSD but largely intact language ability, in kindergarten, a critical time point in their academic development. Furthermore, although one previous study investigated the relationships between LSK and phonological awareness in kindergarten children with SSD and found significant and positive results (Treiman et al., 2008), correlations were calculated across a heterogeneous group of children with SSD in combination with the typically developing control group. Therefore, the present study aimed to extend this previous work by assessing children’s knowledge of all letter names and sounds, evaluating differences in their levels of phonological awareness, and differentiating the individual relationships
between alphabet knowledge and phonological awareness, specifically for children with SSD.

The first two research questions of the present study examined alphabet knowledge in children with SSD by comparing levels of letter name and letter sound knowledge, as well as examining differences in alphabet knowledge across letter name categories (CV, VC, NA, and vowel). Results showed that children with isolated SSD demonstrate high levels of accuracy when producing the letters and sounds of the alphabet, and also demonstrate patterns of knowledge that resemble patterns reported in children with typical development. Based on the existing literature that many children exhibit deficits in phonological awareness, the third research question sought to ascertain whether this difficulty was present for both levels of phonological awareness or was specific to phoneme awareness, as has been alluded to in previous studies (e.g., Hesketh et al., 2000). Results showed that despite a range of ability in the present sample, children with SSD demonstrated overall greater accuracy with deleting larger-sized units from words than phonemes. Findings from the fourth research aim showed that relationships between both letter name and letter sound knowledge and phonological awareness were similar, but weaker than what has been reported in some previous studies (e.g., McBride-Chang, 1999; Treiman et al., 2008).

The following paragraphs further discuss the key findings from the present study as well as their implications in greater detail. Limitations and directions for future research are also addressed.

**Alphabet Knowledge in Children with SSD**
**Letter names and letter sounds.** As hypothesized, kindergarten children with SSD exhibited significant differences between two components of alphabet knowledge such that their knowledge of letter names exceeded their knowledge of letter sounds. This outcome aligns with the existing literature for both typically developing children and those with SSD conducted in the United States (Anthony et al., 2011; Evans et al., 2006; Kim et al., 2011; McBride-Chang, 1999; Treiman & Broderick, 1998). Data from children in other countries where curriculum initially focuses on teaching letter sounds, such as Britain and Greece (e.g., Ellefson et al., 2007, Manolitsis & Tafa, 2011) have shown the opposite pattern, such that knowledge of letter sounds exceeds letter names. These divergent outcomes suggest that acquisition of alphabet knowledge is heavily influenced by direct and formal instruction (Ellefson, Treiman, & Kessler, 2009).

Despite the significant difference between letter name and letter sound knowledge in this study’s participants, it should be noted that overall levels of both aspects of alphabet knowledge were quite high, particularly compared to what has been previously reported in kindergarten children with SSD (e.g., Raitano et al., 2004). For example, Raitano et al. (2004) found that as a group, kindergartners with SSD knew an average of 20.24 letter names and 12.98 letter sounds; whereas children participating in the current study knew an average of 24.88 letter names and 22.75 letter sounds. McBride-Chang (1999) noted that by age 7, most typically developing children have learned all the names of the uppercase letters, and a study by Schatschneider, Fletcher, Francis, Carlson, & Foorman (2004) found that typically developing kindergarten children tested at the end of their school year knew an average of 24 upper case letter names. Although children in
the current study were younger, with a mean age of 6, and although lower case letters were used for the current study’s assessment, the results indicate that these children demonstrated a high level of knowledge about the letters of the alphabet.

**Alphabet knowledge across letter name categories.** The second research question addressed the construct of alphabet knowledge in further detail, in order to assess whether children with SSD exhibited significant differences in letter name knowledge (LNK) and letter sound knowledge (LSK) across letter name categories. The analyses showed that there were no differences in the mean percent correct of LNK across categories; thus children demonstrated similar levels of knowledge about letter names that provided some clue to the associated sound (CV and VC) as those that did not (NA). This was not surprising given the overall high mean total correct for LNK (24.87) and small range (22-26). Furthermore, knowledge of vowel names was at 100% for all children in the study.

Previous research has suggested that there are trends of knowledge patterns for letter names, such that children demonstrate better knowledge about letters in their own names, particularly the first letter of their name (e.g., Justice, Pence, Bowles, & Wiggins, 2006; McBride-Chang, 1999), letters for which the name and sound are associated (e.g., Treiman & Broderick, 1998), and letters that are particularly salient in the environment, or appear earlier in the alphabet (McBride-Chang, 1999). In the current study, levels of letter name knowledge were so high that the influence of any possible differences was no longer detectable.
There were, however, differences in LSK across letter name categories such that knowledge of letter sounds for CV and VC letters was greater than that for NA letters, with LSK of vowels being intermediate; however, only differences between CV and NA LSK were significant. This finding contradicts outcomes in previous studies of children with SSD in some ways. Treiman et al. (2008), for example, found that all kindergarten children with SSD, including those with concomitant language impairment, had greater knowledge of CV than NA letter sounds, with knowledge of VC sounds intermediate, but all category differences were significant. This pattern has also been reported in typically developing kindergartners (Evans et al., 2006), who have been shown to exhibit similar levels of CV and vowel LSK, and that knowledge of both letter name categories was significantly greater than for VC and NA letters. In contrast, the children in the present study did not exhibit differences between knowledge of CV and VC letter sounds, and only the difference between CV and NA letters reached significance. The lack of difference between CV, VC and vowel letters is perhaps due to the generally high level of knowledge about letter sounds demonstrated by the children in the current study. However, a similar outcome has been reported in other studies that have examined effects of explicit letter name and sound instruction on letter sound acquisition (e.g., Piasta & Wagner, 2010; Share, 2004). Although the children in Piasta and Wagner’s study were younger than the children studied in the current study, the group receiving letter name and sound instruction showed similar levels of LSK for letter names containing the sound (i.e., CV and VC), but significantly poorer knowledge of NA letters. It was argued that children who are taught about letter names and sounds will have gained significantly
more knowledge about letters with names containing the associated sound, regardless of whether the sound is at the beginning (i.e., CV letters) or end (i.e., VC letters). Although the extent to which alphabet instruction was provided to children in the present study was not measured, it may very well be that most letters had been taught by the latter half of the kindergarten school year, and that their ability to remember and retain information about letters that have ‘clues’ about the associated letter sound was particularly strong. This interpretation would support the idea that properties within the letter name--specifically, whether the name contains the letter sound or not--impacts children’s abilities to learn those letter sounds (Treiman et al., 1994). Learning letter sounds for letters that provide no hint about its associated sound appeared to be more difficult for children to acquire.

Despite the fact that all children knew all the vowel letter names, their knowledge of associated vowel sounds was lower (85%), and very few children could identify both long and short sounds associated with each vowel letter. Furthermore, LSK of vowels demonstrated by this group of children was primarily limited to the short vowel sounds. This finding conflicts with the theory that children would learn letter sounds that are phonologically similar to the letter names, because short vowel sound might be categorized as NA, and the long vowel sound (which is the letter name itself) should be easier for children to remember (Evans et al., 2006). Categorizing vowels separately, however, is appropriate, as Share (2004) notes that vowel letter names do not contain consonants, and do not actually neatly fit in to any other category. Previous studies assessing LSK either do not include vowels in their assessment, accept only one type of
sound (long or short) as correct (e.g., Kim et al., 2010), or note that either long or short sounds are accepted as correct (e.g., Evans et al., 2006). Therefore, placing the outcomes of the present study into a broader context is difficult. It is possible, however, that because children understood general properties about how letter names and letter sounds are associated (i.e. that the sounds may be similar to, but are distinct from, the letter name), producing the long vowel sound may have seemed incorrect.

**Phonological Awareness in Children with SSD**

Despite the high levels of both letter names and letter sounds across the categories, levels of phonological awareness were not as uniformly strong in this group of children with SSD. This was not unexpected given the considerable evidence that many children with SSD have poorer phonological awareness than typically developing children (Anthony et al., 2011; Bird et al., 1995; Hesketh et al., 2000; Raitano et al., 2004). Results from this study, however, showed that children with SSD demonstrated significantly greater accuracy on items on an elision task that required deletion of words and syllables, as opposed to deletion of phonemes. Previous studies have also shown that children with SSD have difficulty with phoneme deletion tasks. Hesketh and colleagues, for example, noted that children with phonologically based speech disorder had significantly poorer scores on two phoneme tasks as compared to rhyming, onset matching, and phoneme blending tasks. However, their elision task only included phonemes, and did not compare the children’s ability to delete larger phonological units, such as words and phonemes. Additionally, the children in their study were younger, with a mean age of 48.13 months, and even the control group had difficulty with the task;
thus, they may have been too young to fully understand the task requirements or their
reduced exposure to experiences that foster phonemic awareness may have been reduced
relative to the older children used in the current study. Although several studies have
examined phonological awareness in children with SSD, there has been no other study to
my knowledge that isolated within-group differences between levels of phonological
awareness to identify the possibility of particular deficits with phoneme awareness.
Because the cognitive operation required for this task was constant in the present study, it
was clear that the difference was due to the size of the phonological structure, and not the
demands of the task itself.

This outcome could be interpreted in at least two ways. First, it is possible that
this group of children, who demonstrated greater ability on items requiring word and
syllable deletion, had not as yet developed phoneme awareness to the degree that the
selected task required. There is strong evidence for a developmental progression in
acquiring levels of phonological awareness (e.g., Anthony et al., 2003), with phoneme
awareness being the last, or deepest, level. Because most children showed some level of
proficiency with the larger-sized units, it is possible that the timing of the current
assessment was at a developmental stage prior to the onset of phonemic awareness.

A second interpretation, however, is that some children with SSD might
demonstrate specific deficits in phoneme awareness. Several theories of how
phonological structure develops in children converge on the notion that the process
involves acquiring narrower, more refined attention to phonological details, and thus
more differentiated phonological representations (e.g., Menn, 1983; MacNeilage &
As children’s vocabularies increase, representations become more fine-tuned from words, to syllables, to onsets and rimes, and eventually phonemes, as does their awareness to these differently sized units (Studdert-Kennedy, 1987). Critical to these theories, however, is that language and speech experience motivates the developmental process. Children whose speech sound development is deviant in some way, then, may be at risk for poor phonological awareness, even with normal cognitive and language skills. Thus, it is possible that their attunement to larger structures had not been impacted, but that their representations for smaller units, such as phonemes, were not as well specified.

Despite the possibilities for explaining the differences on the phonological awareness task, however, it is interesting that the mean score on this particular elision task by this group of children with SSD was quite high, compared to normative data provided by Catts, Fey, Zhang and Tomblin (2001). Mean scores for typically developing children between the ages from 5;0 to 6;11 ($n = 1,507$) from a 1997 study (Tomblin et al., 1997), ranged according to age group, from 7.58 (6.2) to 9.92 (6.52), respectively. Although the present sample was very small, the children in this study achieved a higher mean score ($M = 12.56, SD = 5.25$) than the children in the Catts et al. (2001) study. Reasons for this greater performance are purely speculative; however, it is possible that research highlighting strong connections between phonemic awareness and word decoding have influenced curriculum standards to include explicit instruction on phoneme awareness in kindergarten. The Ohio academic content standards were redesigned in 1997 and suggest the inclusion of explicit phonemic awareness instruction.
in order to facilitate early reading skills (Ohio Department of Education, 2012) which may not have been in place at the time of Tomblin and colleagues (1997) epidemiological study, but have since positively impacted children’s abilities on this type of task.

As an additional explanation for the high levels of performance of children in this study, all children in the present study had been receiving speech sound interventions for at least 6 months. Although data concerning the scope and intensity of these interventions were not collected, it is possible that interventions that include either implicit or explicit focus on phonological awareness training could have resulted in increased ability on phonological awareness tasks. Gillon (2000), for example, found that preschool children with SSD who had been receiving phonological awareness intervention had higher levels of phonemic awareness and word decoding skills in first grade, compared to children with SSD whose intervention did not include those elements. Thus, the positive impacts that such interventions may have on children can be significant and long lasting.

Finally, although some children did well on the phonological deletion task, several children did very poorly on this measure overall, and the range of ability was particularly noticeable for items requiring phoneme deletion. This finding is not unusual, as many previous studies have shown that subgroups of children with SSD exhibit variable strengths and deficits (e.g., Hesketh et al., 2000; Nathan et al., 2004; Rvachew, 2007). Given the predictive power of the phoneme deletion task to later reading ability (e.g., Catts et al., 2001; Hogan et al., 2005; Hulme et al., 2002), however, it was of interest to explore this variability in greater detail.
In a post-hoc analysis, when children were subgrouped according to the number of speech sound errors based on their GFTA-2 scores, group differences on either level of phonological awareness were not found. However, children who demonstrated phonological processes that were atypical and/or very delayed for their age (i.e. backing, final consonant deletion) had significantly poorer scores on the phonological awareness task, for both larger structures and phonemes, than those with typical but minimally delayed developmental phonological processes. This outcome accords with a considerable body of literature suggesting that the children who are most likely to demonstrate difficulty in phonological awareness tasks are those whose speech production includes nondevelopmental, or atypical, errors (Holm, Farrier & Dodd, 2008; Preston & Edwards, 2010). Errors such as these indicate that the system of how the child has organized or accesses phonological representations is compromised in some way. Similar outcomes were reported by Holm, Farrier and Dodd (2008), who examined the phonological awareness abilities (syllable segmentation, rhyme awareness and alliteration awareness) of 62 children with speech difficulties, who were further classified according to their error types (delayed, atypical errors, inconsistent errors) and a control group. The speech-disordered children as a group had lower phonological awareness skills than typically developing children, and those exhibiting consistent yet atypical errors had the lowest scores of all groups. Research supporting the “critical age hypothesis” suggests that children whose speech difficulties persist to the ages of 5-6 (Bishop & Adams, 1990; Raitano et al., 2004), as in the children in the present study, are likely to exhibit poor phonological awareness as well. However, results of the present study suggest that even
within a group of children with SSD who have reached that “critical” age, there will still be considerable variability in phonological awareness skills.

Although the subgroups based on phonological error patterns differed on phonological awareness, they did not differ with respect to levels of alphabet knowledge. This finding suggests that in children with speech impairments and poor phonological awareness, normal language and cognitive skills might serve to protect children from deficits in the development of other early literacy skills. An explanation offered by Bird et al. (1995) suggests that children with speech impairments who have higher IQ and language abilities are able to generate an alternative strategy to offset their poorer PA abilities. In other words, those with speech disorders and poor PA skills are still at an advantaged position to draw on other resources to acquire sufficient early literacy skills, as compared to those with concomitant language and speech deficits. This assertion was supported by findings in Raitano et al. (2004), when assessing whether SSD (with and without language impairment) would impact performance on pre-literacy measures. It was found that children with normalized SSD continued to perform less well than the control group on PA scores, but as well as controls on the letter knowledge task. In contrast, those with additional risk factors (i.e. language impairment of low IQ) had the lowest scores and more widespread difficulties. Raitano and colleagues concluded that deficits in PA may persist in children with either or both disorders, but variables such as IQ and language impart additive negative effects on the development of word decoding skills.

**Relationships between alphabet knowledge and phonological awareness**
Similar to what has been shown in many studies of typically developing kindergarten children (e.g., Blaiklock, 2004; Evans et al., 2006; McBride-Chang, 1999; Treiman et al., 2008), the present study found that letter sound knowledge was moderately to strongly correlated with phonological awareness in kindergartners with SSD ($r = .38$), although the coefficients reported for this group of children with SSD are weaker in magnitude than what has been previously reported. For example, Evans et al. (2006) found that knowledge of lower case sounds and a composite phonological awareness score administered to Canadian children near the end of their kindergarten year were strongly and positively correlated ($r = .63$). Similarly, McBride-Chang (1999) reported that relationships between LSK of uppercase letters and performance on a elision task measured at the end of the kindergarten year were also strong and positive ($r = .53$). Although the present study found a more moderate relationship between LSK and the mean total score for the phonological awareness task ($r = .38$), the overall higher mean scores for LSK for the current group of children compared to those in the two aforementioned studies, as well as the smaller sample size, may have prevented the detection of stronger relationships. The children in McBride-Chang’s (1999) study had levels of LSK similar to the group of children in the current study by the end of first grade; at that time, the relationship between LSK and the elision task was weaker, and identical to the coefficient reported here ($r = .38$). The differences in how these two skills correlate over time and skill development suggests that perhaps the relationships are strongest as children are still in the stages of early acquisition of LSK, but that the
correlation diminishes once children reach a certain level of competence in their knowledge about letter sounds.

The fact that these correlations differ as a function of skill level is further corroborated by the outcome that age was only weakly correlated with LNK, LSK, and phonological awareness. Rather, speech skills were more strongly related to the experimental variables, particularly for LSK and phonological awareness of larger structures. Specifically, children with fewer speech sound errors and phonological processes had stronger knowledge about letter sounds and greater accuracy on the phonological awareness task. These findings are not unexpected given the existing literature showing that children with SSD often have poor phonological awareness (e.g., Bird et al., 1995; Hesketh et al., 2004; Nathan et al., 2004) and thus supports this line of research. The strong relationship between the number of phonological processes and LSK has not been previously reported in the literature about children with SSD, although a few studies examining preschool children with speech impairment have found poorer outcomes when compared to typically developing children for measures of LSK (Bird et al., 1995; Carroll & Snowling, 2004). Furthermore, although the children’s scores on the standardized articulation test (GFTA-2) and the phonological process analyses (KLPA-2) were very strongly correlated with each other, the magnitude of the relationships between each of those measures to LSK differed and was strongest for the KLPA-2. This outcome supports the idea that acquiring LSK involves some degree of phonological awareness and further suggests that children with phonologically-based speech sound errors are likely to encounter difficulty in learning and retaining information about letter sounds.
As discussed earlier, LNK in the current group of children with SSD was nearly at ceiling, and higher than expected, given previous reports of outcomes from both typically developing children and children with in kindergarten (Catts et al., 2001; Evan et al., 2006; Foy & Mann, 2012; McBride-Chang, 1999). It has been suggested by some researchers that ceiling effects on skills such as letter naming will minimize the strength of relationships between that variable to other tested variables (Damon, Lerner, Renninger, & Sigel, 2006). The negative correlation coefficients between LNK and phonological awareness reported here support the idea that a ceiling effect might have masked the actual degree of correlation between LNK and phonological awareness ($r = -0.209$); thus, these data should be interpreted with extreme caution.

**Relationships between categories of LSK and levels of phonological awareness.**

In previous work, Treiman et al. (2008) found that for a group of kindergartners, a composite phonological awareness score was significantly correlated with LSK of three letter name categories (CV, VC, NA); however, these correlation coefficients were calculated across their entire sample, including children with SSD, children with SSD and language impairment, children whose speech problems had resolved, and typically developing children. Therefore, to date, no previous study has examined the relationships between categories of LSK and levels of phonological awareness specifically in children with SSD. Overall, the correlations coefficients between phonological awareness and categories of LSK in the present study were much smaller than those reported in Treiman et al. However, the results reported here did show that
both levels of phonological awareness, but particularly phoneme awareness, were most strongly correlated with LSK of CV letters, and were weakly correlated with LSK of other categories (VC, NA and vowels). This finding underscores that the name to sound relationship is perhaps most evident for CV letters than for other categories, and particularly so for children with deeper levels of phonological awareness, which is similar to findings that phoneme awareness and CV letter sounds are strongly correlated in typically developing children (e.g., Share, 2004).

In sum, the present study found that children with isolated SSD exhibit a range of ability on the phonological deletion task, but that their accuracy for items requiring word or syllable deletion was significantly greater than accuracy for phoneme deletion. Additionally, despite the performance variability within this small sample of children, those with atypical speech errors had the lowest scores on both levels of phonological awareness. Results from the present study suggest that despite a high overall degree of alphabet knowledge and normal language, children with SSD may still be at risk for poor phoneme awareness, which is an important skill for word reading ability. An important implication from these outcomes is that phonological awareness skills should be assessed in kindergarten children with SSD, in order to consider their potential risk for deficits in phoneme awareness, which would likely impact the development of their word decoding abilities. Another important implication from these analyses is that severity of speech errors in terms of number of errors alone will not distinguish which children face this risk, but that consideration of the types of exhibited speech errors may impart more meaningful insight for this purpose. This study provides additional support for the need
to examine and characterize the nature of speech errors in order to understand their possible risks and challenges. Thus, if clinicians can address the potential for phonemic awareness deficits in this population of children, it is hopeful that they would be able to develop the skills required for word decoding, and prevent poor reading outcomes at a later stage.

**Limitations & Future Directions**

Despite this study’s contributions to increasing our knowledge about the strengths and challenges faced by children with isolated SSD on measures of early word decoding skills, several limitations to the present study should be noted in order to inform future research. First, the sample size for this study was quite small, which may have restricted significant correlations between phonological awareness and levels of LSK. The planned sample size for this project was for 30 participants; however, because the inclusion criteria for this study were specific in order to isolate the impacts of SSD on early decoding skills, many fewer than expected children met these criteria. As such, the reported results are likely to accurately reflect the skills and abilities of children with SSD and can be generalized to the number of children who meet that criterion. Although many studies often include children with SSD who have a range of language ability, the proportion of all children with SSD who exhibit concomitant SSD and language impairment is considerably lower than those with isolated SSD (Dodd, 2005).

Second, the variables of interest in this study were assessed at a single time point and within a short period of time to prevent confounds from curricular effects. The purpose of this design was to assess the strength and deficits of early word decoding
skills in kindergartners with SSD and control, as much as possible, curricular effects. However, in order to learn more about the development of these word decoding skills over time, future studies might incorporate a longitudinal design, and include a standardized reading measure to obtain information about the predictive nature of alphabet knowledge and phonological awareness to reading ability, especially decoding, in children with SSD. The current study was also limited in that information was not obtained about children’s exposure to phonological awareness activities, and the extent of their alphabet instruction. This was difficult to do, since children were recruited from a variety of sources, and parent report on their child’s learning and curriculum may not have been reliable. Future studies should consider best methods for attaining that information so those influences can be appropriately accounted for.

Third, although recent studies (e.g., Kim et al., 2010; Piasta & Wagner, 2010) have evaluated children’s alphabet knowledge using cross-classified multilevel models (CCMLMs), which allow for the partitioning of variance among students and among letter name categories, the present study utilized a correlational design, and compared averaged percentages correct for each variable. This was done in order to closely compare results to that of similar studies examining these variables in this population (e.g., Treiman et al., 2008). Future directions include utilizing a multi-level model to analyze the current data.

Finally, the current study utilized a within-subjects design, consisting only of children with SSD. The background literature used to support the study’s research questions outlined the research that has addressed similar questions of how PA and AK
develops in typically developing children, highlighting the gap that exists in the current research base concerning the status of these skills in children with SSD. As such, the questions of interest focused solely on contributing to knowledge about the relationships between these early literacy skills in children with SSD. Of particular interest for future research is expansion of the findings from the post hoc analysis of the impacts of atypical and severely delayed speech errors on phonological awareness. However, future research, or perhaps retrospective data, might be used to draw comparisons between children with SSD and typically developing children as well as children with language impairment, to more fully understand the differences between these groups, and provide a broader perspective of these skills in kindergarten children. Additionally, future work should consider or account for varying speech errors in children with SSD in order to gain additional information about the relationships between specific phonological processes and effects on word decoding ability.

**Significance and Conclusions**

The present study investigated alphabet knowledge and phonological awareness, and the extent to which these skills were related, in kindergarten children with speech sound disorders. Although previous studies had looked at these variables in children with SSD, the inclusion of some children with concomitant language impairment and low IQ have made it difficult to assess the degree to which these skills are affected in these children. Additionally, previous work had not provided a complete assessment of all letters of the alphabet. Thus, the present study provided a comprehensive evaluation of the studied children’s letter name and letter sound knowledge. Second, the present study
explored within-group differences on a phonological awareness task, in order to determine the extent to which children with SSD may demonstrate specific difficulties with phoneme manipulation as opposed to phonological units of larger size. Although previous studies had examined performance on different types of PA tasks, the present study utilized a single task to cleanly measure this difference. The finding that children exhibited some levels of phonological awareness, but did significantly poorer on phoneme tasks suggests that future research should continue to explore how this aspect of phonological awareness develops and impacts reading ability for children with SSD.

This study has both clinical and theoretical importance, as it has helped to further our understanding of how speech sound disorders may impact the early decoding skills in young children with SSD. For instance, this study provided additional evidence for the need to assess and evaluate the types of errors exhibited by children with this disorder, as post-hoc analysis revealed that subgroups differed as a function of error type, but not speech error frequency on a commonly used test. This research indicates that severely delayed phonological processes, as well as atypical processes, may place children at increased risk for developing some early literacy skills. Additionally, the strong relationship between speech sound errors and phonological processes to letter sound knowledge suggest that clinicians should pay specific attention to how children with phonological disorders develop LSK, as that is a critical component to word decoding that might be significantly impacted in children with severe phonological disorders.
The findings from this study make a notable contribution to the existing knowledge base regarding the early word decoding skills in young children with SSD, as well as the subskills, which may pose specific challenges in their early reading development. Importantly, children with SSD in the present study exhibited strong levels of alphabet knowledge, despite some difficulties in phonemic awareness. Future research should expand on the work presented here to longitudinally examine the nature of these variables and their connections to reading in children with SSD and continue to find ways to optimize their reading success.
References


Savage, R. (2006). Reading comprehension is not always the product of nonsense word decoding and linguistic comprehension: Evidence from teenagers who are extremely poor readers. *Scientific Studies of Reading, 10*, 143-16.


Appendix A. Parent Questionnaire
Appendix A: Parent Questionnaire

Thank you for participating in our study. This short questionnaire is intended to provide some background demographic information about the participants as a group. No individual or identifying information will be published.

**Family Background**

1) **Mother/primary caregiver’s occupation:** ______________________

2) **Mother/primary caregiver’s highest degree or level of school completed:**
   - Junior high school
   - High school or GED
   - Some college
   - Associates degree
   - Bachelors degree
   - Master’s degree
   - Doctoral degree
   - Professional degree (MD, DDS, DVM, LLB, JD)

---

**About my child**

1) **Full name:** ____________________________

2) **Birth date:** ____________________________

3) **Gender:** ____________________________

4) **My child is currently attending Kindergarten:**
   - Full day
   - Part-day
   - N/A

5) **English is the only language spoken in our home:** Yes / No

6) **My child speaks less well than his/her peers:** Yes/No

7) **The major communication and learning problem my child has is a problem in producing and using speech sounds in talking:** Yes/No

8) **My child was diagnosed with a speech disorder or delay at age _____________.
9) My child has been receiving speech therapy for:

   More than 1 year  6 months  less than 6 months  N/A

10) My child has no other developmental disabilities: Agreed / Not Agreed

   If not agreed, describe________________________

11) My child does not have, and has no history of, hearing loss or impairment:

   Agreed / Not agreed

   If not agreed, describe: __________________________________________________

   **About my child’s alphabet knowledge and reading ability**

12) My child knows the *names of*:

   Very few letters of the alphabet   Most of the letters
   Some of the letters               All of the letters

13) My child knows the *sounds of*:

   Very few letters of the alphabet   Most of the letters
   Some of the letters               All of the letters

14) My child can read a Level 1 Primer

   With a lot of help                   Completely on his/her own
   With only a little help             N/A – my child is not yet reading
Appendix B. Catts Deletion Task (Catts et al., 2001)
Appendix B. Catts Deletion Task (from Catts et al., 2001)

The child is shown a picture of a cow and a boy and asked to say “cowboy.” After the child responds, the examiner covers the cow and says, “Now say cowboy without the cow.” The procedure is repeated with the picture of a tooth and a brush (toothbrush) and a cup and a cake (cupcake). If the child fails a practice item, the examiner provides the appropriate response. After completing the practice items, the examiner asks the child to say each of the test items after deleting the portion that is underlined. In all cases, the portion to be deleted is referred to phonetically (e.g., “say seat without /s/”). No pictures are used for the test items and no feedback is provided. Testing is discontinued following six consecutive errors.

Test Items:

1. baseball
2. haircut
3. Sunday
4. railroad
5. sometime
6. return
7. around
8. motel
9. almost
10. helpful
11. baby
12. person
13. monkey
14. fat
15. seat
16. shout
17. tall
18. door
19. few
20. snail
21. thread
Appendix C. Results from the Shapiro-Wilk Tests for Nonnormality
### Appendix C. Results from the Shapiro-Wilk test of normality

<table>
<thead>
<tr>
<th>Variable</th>
<th>Shapiro-Wilk test statistic</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catts – larger structures</td>
<td>.873</td>
<td>.030</td>
</tr>
<tr>
<td>Catts – phonemes</td>
<td>.885</td>
<td>.046</td>
</tr>
<tr>
<td>LNK total</td>
<td>.829</td>
<td>.007</td>
</tr>
<tr>
<td>LSK total</td>
<td>.899</td>
<td>.078</td>
</tr>
<tr>
<td>LNK-CV</td>
<td>.758</td>
<td>.001</td>
</tr>
<tr>
<td>LNK – CV</td>
<td>.546</td>
<td>.000</td>
</tr>
<tr>
<td>LNK-NA</td>
<td>.430</td>
<td>.000</td>
</tr>
<tr>
<td>LNK-vowel (values were</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>constant)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSK – CV</td>
<td>.621</td>
<td>.000</td>
</tr>
<tr>
<td>LSK-VC</td>
<td>.774</td>
<td>.001</td>
</tr>
<tr>
<td>LSK-NA</td>
<td>.903</td>
<td>.091</td>
</tr>
<tr>
<td>LSK-vowel</td>
<td>.621</td>
<td>.002</td>
</tr>
</tbody>
</table>
Appendix D. Results from Nonparametric Analyses
Appendix D. Results from nonparametric analyses

Research Question 1. Do children with SSD differ in their knowledge of letter sounds (LSK) and letter names (LNK)?

The Wilcoxon Signed-ranks test determined that this difference was significant ($Z = 2.765, p = 0.006$), with 11 children demonstrating greater letter name ($\text{Mdn} = 25$) over LSK ($\text{Mdn} = 22.5$), 2 children demonstrating better letter sound over letter name knowledge, and 3 children whose knowledge of letter names and sounds was equal.

Research Question 2. Does their LSK differ by letter name categorization reflecting the way in which the letter name encodes a sound associated with the letter?

Results from the Friedman’s ANOVA showed that levels of LSK were significantly different across letter name categories ($X^2(3) = 9.504, p = .023$). Post-hoc analysis using a series of Wilcoxon Signed-Rank Tests was conducted. Applying a Bonferroni correction set the significance value at $p < 0.0125$. Comparisons between categories revealed that percentage correct for LSK of CV letters ($\text{Mdn} = 100$) was significantly greater than percentage correct for LSK of NA letters ($\text{Mdn} = 81.5$) ($Z = 2.831, p = .005, r = .70$); this was the only significant difference between letter categories. Although either vowel sound (short or long) was accepted as correct, children were asked to produce both. Children exhibited greater percentage correct for LSK of short vowel sounds ($\text{Mdn} = 80$) as compared to long vowel sounds ($\text{Mdn} = 0$); a Wilcoxon Signed-Ranks test confirmed this difference to be significant ($Z = 3.442, p = .001, r = .86$).
Research Question 3. Do children with SSD perform differently on two parts of a phonological elision task, in which the size of the deleted structure varies (words and syllables versus phonemes)?

A Wilcoxon Signed-Ranks test confirmed that this difference was statistically significant ($Z = -2.431, p = .015, r = .61$).

Research Question 4. Is children’s accuracy on LSK for each of the 4 letter-name categories (CV, VC, NA and vowel) related to their accuracy on 2 elision tasks (one involving deletion of words and syllables and the other involving single sounds)?

Correlation coefficients from the Kendall tau’s calculations are presented below.

Performance on the phonological elision task for either larger or smaller structures does not correlate with knowledge about any category type for either letter name knowledge or LSK. Thus, no further calculations examining predictors of phonological awareness skills were done.
**Kendall’s tau correlation coefficients between measures of phonological awareness and LSK**

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Catts –</td>
<td>-</td>
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<td></td>
<td></td>
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<tr>
<td>larger structure</td>
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<tr>
<td>2. Catts -</td>
<td>0.404*</td>
<td>-</td>
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<td></td>
<td></td>
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<tr>
<td>phoneme</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3. LSK-CV</td>
<td>0.216</td>
<td>0.302</td>
<td>-</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>4. LSK-VC</td>
<td>0.145</td>
<td>0.066</td>
<td>0.497*</td>
<td>-</td>
<td></td>
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</tr>
<tr>
<td>5. LSK-NA</td>
<td>0.147</td>
<td>0.282</td>
<td>0.385</td>
<td>-</td>
<td></td>
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<tr>
<td>6. LSK-</td>
<td>-0.034</td>
<td>0.090</td>
<td>0.503*</td>
<td>0.468*</td>
<td>-</td>
<td></td>
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<tr>
<td>vowel</td>
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<tr>
<td>7. LNK-CV</td>
<td>-0.134</td>
<td>0.033</td>
<td>0.672**</td>
<td>0.154</td>
<td>0.101</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8. LNK-VC</td>
<td>-0.313</td>
<td>-0.338</td>
<td>0.149</td>
<td>0.163</td>
<td>0.014</td>
<td>0.429</td>
<td>0.098</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>9. LNK-NA</td>
<td>0.185</td>
<td>0.183</td>
<td>0.000</td>
<td>0.265</td>
<td>0.311</td>
<td>0.199</td>
<td>0.018</td>
<td>-0.271</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10. LNK-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>vowel</td>
<td></td>
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</tr>
</tbody>
</table>

*Note.* Catts = Catts deletion task (Catts et al., 2001), LNK = letter name knowledge, LSK = letter sound knowledge, CV = consonant-vowel letter names; VC = vowel-consonant letter names, NA = no association letter names.

*p < .01.*

**p < .001.*
Appendix E. Description of Phonological Processes
### Appendix E. Description and examples of children’s phonological processes

<table>
<thead>
<tr>
<th>Phonological Process</th>
<th>Example</th>
<th>Description</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BK</strong> = Backing to velars</td>
<td>/tri/ -&gt; /kri/</td>
<td>A palatal sound is replaced with a back sound</td>
<td>Atypical</td>
</tr>
<tr>
<td><strong>CS</strong> = cluster simplification</td>
<td>/spun/ -&gt; /pun/</td>
<td>One sound in a consonant cluster is omitted</td>
<td>Typical</td>
</tr>
<tr>
<td><strong>DF</strong> = deaffrication</td>
<td>/watʃ/ -&gt; /waʃ/</td>
<td>An affricate is replaced by another sound</td>
<td>Typical</td>
</tr>
<tr>
<td><strong>DFC</strong> = deletion of final consonants</td>
<td>/dʌk/ -&gt; /dʌ/</td>
<td>The final consonant of the word is deleted</td>
<td>More delayed</td>
</tr>
<tr>
<td><strong>IV</strong> = initial voicing</td>
<td>/kar/ -&gt; /gar/</td>
<td>A voiceless sound before a vowel is voiced</td>
<td>More delayed</td>
</tr>
<tr>
<td><strong>LIQ</strong> = liquidization</td>
<td>/jɛlo/ -&gt; /lɛdo/</td>
<td>A glide is replaced by a liquid sound</td>
<td>Typical</td>
</tr>
<tr>
<td><strong>LS</strong> = liquid simplification</td>
<td>/rɪŋ/ -&gt; /rɪŋ/</td>
<td>Liquid sounds are replaced by glides</td>
<td>Typical</td>
</tr>
<tr>
<td><strong>PF</strong> = palatal fronting</td>
<td>/fiʃɪŋ/ -&gt; /fɪsɪŋ/</td>
<td>Palatal sounds are replaced with an alveolar sound</td>
<td>More delayed</td>
</tr>
<tr>
<td><strong>ST</strong> = stopping</td>
<td>/fɛðɔ/ -&gt; /fɛdɔ/</td>
<td>Sound is replaced with a stop sound</td>
<td>Typical</td>
</tr>
<tr>
<td><strong>STR</strong> = stridency deletion</td>
<td>/spun/ -&gt; /θpun/</td>
<td>Palatal sound is replaced with another sound</td>
<td>Typical</td>
</tr>
<tr>
<td><strong>VF</strong> = velar fronting</td>
<td>/kʌp/ -&gt; /tʌp/</td>
<td>A back sound is replaced with a palatal sound</td>
<td>More delayed</td>
</tr>
</tbody>
</table>