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Lexical Characteristics of Words and Phonological Awareness Skills of Preschool Children

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COLLEGE OF ARTS AND SCIENCES

LEXICAL CHARACTERISTICS OF WORDS AND PHONOLOGICAL AWARENESS
SKILLS OF PRESCHOOL CHILDREN

By

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ABSTRACT

The Lexical Restructuring Model (LRM; Metsala & Walley, 1998) attempts to explain the development of phonological awareness. According to the LRM, as children's vocabularies increase, children develop a more refined lexical representation of the sounds of which those words are comprised, and, in turn children become more sensitive to the detection of specific phonemes. The LRM identifies several lexical characteristics of words that influence children's phonological awareness skills: age of acquisition (AoA), word frequency, neighborhood density, and phonotactic probability. In this study, the effects of these lexical characteristics on children's performance on phonological awareness tasks were evaluated. Additionally, moderation of these effects by children's oral language skills and ages was tested. This study involved two independent samples of preschool children ($Ns = 392$ and 814) who completed measures of phonological awareness (blending and elision) and oral language. For both samples, AoA and word frequency were negatively related to phonological awareness skills, and phonotactic probability was positively related to phonological awareness skills. Children's ages and oral language skills were positive predictors of phonological awareness skills, and children's ages moderated the relations between AoA and phonological awareness skills for children in Sample 2. Children's oral language skills moderated the relations between AoA and phonological awareness skills for children in Sample 1. Results for AoA and phonotactic probability were consistent with the LRM; however, results for word frequency and neighborhood density were not. Implications and potential necessary re-conceptualizations of the LRM are discussed.

Keywords: Phonological awareness, lexical restructuring model, neighborhood density, age of acquisition, word frequency, phonotactic probability

CHAPTER ONE

INTRODUCTION

Literacy is an essential skill required to succeed in school and life, and assessment of literacy skills is important to identify children who may be at-risk for reading difficulties. The ability to read proficiently can profoundly affect the life of an individual. In modern society, reading is a necessity for obtaining many jobs, accessing important information, and improving overall quality of life. Early in life, the ability to read allows children to succeed in school. Reading is not only required for English and language arts classes but information in other content area classes is often provided in the form of text, making literacy an essential skill for continuing to acquire knowledge in these areas and performing well in school. Children who have reading difficulties early in life will often continue to fail to comprehend text at an appropriate level later in life without the proper intervention and additional instruction to alleviate these difficulties. It is important to continue to develop an understanding of how children learn to read to be able to assess and identify their strengths and weaknesses accurately within critical domains of early reading development to potentially alleviate risk for later reading difficulties.

Research in the past few decades has helped to describe the development of reading skills by identifying and defining the skills that are the precursors to literacy (Snow, Burns, & Griffin, 1998; Wagner & Torgesen, 1987; Whitehurst & Lonigan, 1998). Emergent literacy skills are those reading- and language-related skills that develop before formal reading instruction begins (Whitehurst & Lonigan, 1998). In particular, three emergent literacy skills have been identified as the strongest predictors of later reading ability: phonological awareness, oral language, and print knowledge. Phonological awareness is children's ability to detect and manipulate the sounds of speech, independent of their semantic properties. Oral language includes children's vocabulary knowledge as well as skills in the areas of syntax, morphology, phonology, and pragmatics, and children's ability to use these skills to express meaning and understand spoken language. Print knowledge includes children's letter and sound knowledge as well as their knowledge about conventions of print (e.g., text is read from left to right and top to bottom, which part of a book is the front).

Among emergent literacy skills, research indicates that phonological awareness is particularly important for the development of early reading skills (Whitehurst & Lonigan, 1998). Phonological awareness is a code-related skill (i.e., those skills related to breaking the alphabetic code and reading print), and children who can better detect the individual sound components of words acquire stronger abilities to decode print (i.e., read) earlier in life. Evidence shows that this finding holds even after controlling for intelligence, memory skills, vocabulary skills, and socioeconomic status (Bryant, MacLean, Bradley, & Crossland, 1990; MacLean, Bryant, & Bradley, 1987; Wagner, Torgesen, & Rashotte, 1994). In addition, experimental research has suggested that phonological awareness skills play a causal role in children's acquisition of English literacy skills (Byrne & Fielding Barnsley, 1991, 1993, 1995). Furthermore, it appears that the relationship between phonological awareness and reading ability is reciprocal; as children's phonological awareness skills develop, they become more proficient at decoding print, and in turn, as children become better at decoding print, their phonological awareness skills continue to improve (Perfetti, Beck, Bell, & Hughes, 1987; Wagner et al., 1994). Therefore, if children lack sufficient phonological awareness skills to decode print at any particular level, they will continue to fall behind their peers because they will not gain the reading experience that is necessary for the continuous development of phonological awareness.

Despite its importance in the development of reading, little is known about the developmental origins of phonological awareness. One theory that attempts to explain the development of phonological awareness is the Lexical Restructuring Model (LRM; Metsala & Walley, 1998). In general, the LRM proposes that as children's mental lexicon grows their mental representations of words shifts from a holistic nature to an increasingly fine-grained and segmented nature. According to LRM, the individual phoneme is an emergent unit of sound that is at first used perceptually to identify and represent speech and only later can be accessed as a cognitive unit to assist with reading (Walley, Metsala, & Garlock, 2003). Phonological awareness skills, as well as the ability to use these skills to read, are limited by the developmental status of the mental representation of the phoneme (Walley, 1993; Walley et al., 2003).

In addition to the restructuring from a holistic mental representation of words to an increasingly segmented representation, there are three other components that are associated with restructuring according to the LRM (Walley et al., 2003). First, the restructuring of children's

conceptualization of words is subject to individual differences because it is dependent upon vocabulary growth. This dependence causes changes to take place on an individual word-level basis rather than uniformly throughout a child's mental lexicon, as there are different lexical characteristics of words that influence this shift (e.g., word frequency, phonological neighborhood density). Second, the restructuring of the mental lexicon and change in conceptualization of the nature of words is a precursor to the continuous development of phonological awareness skills. Third, the development of phonological awareness is not caused by reading experience; reading experience contributes to the further refinement and maintenance of phonological awareness. As children continue to develop reading skills and their vocabulary increases, they become familiar with words that are phonologically similar to words they already know, making it necessary for them to keep these words distinct from each other, which often requires the ability to detect inter-word differences of a single phoneme (e.g., lap, map, man).

Words have different lexical characteristics, including word frequency, age of acquisition (AoA), phonological neighborhood density, and phonotactic probability. Word frequency refers to how often an individual word is heard in everyday speech or seen in text. AoA refers to the average age at which an individual acquires any particular word. Word frequency and AoA are often highly correlated, but they are distinct lexical characteristics (Walley et al., 2003). Walley et al. (2003) use the word "cartoon" to illustrate this point. Most children acquire this word early in life, but it is not a word that is frequently encountered in speech or text. Phonological neighborhood density refers to the number of words that differ from the target word by only one phoneme (versus more than one phoneme). Words that have many words that differ by only one phoneme have dense neighborhoods (e.g., lime, time, light, life, etc.). Phonotactic probability is the frequency with which phonological segments, as well as sequences of phonological segments, occur in a specific language (Vitevitch & Luce, 2004). Like word frequency and AoA, phonotactic probability and phonological neighborhood density are similar, but distinct, constructs. Words with many neighbor words varying by only one phoneme will oftentimes also have a high phonotactic probability (segments of phonemes within those words have a high probability of occurring in that language).

Based on LRM, children's phonological awareness skills should be dependent upon the words that children know. As their mental lexicon increases, they encounter more words that are similar to each other, requiring a restructuring of the mental lexicon and a shift toward a more

fine-grained mental representation of words (i.e., representations of individual phonemes that comprise words should develop). Because of this restructuring, children's phonological awareness skills should be impacted by these various lexical characteristics of words.

Research supporting the claim that children's mental lexicon undergoes restructuring has focused primarily on how specific lexical characteristics of words affect performance on spoken word recognition tasks. Walley and Metsala (1990, 1992) divided words into early-, current-, and late-acquired words. Words were selected based on adults' subjective ratings, such that if adults estimated a word was learned at 3 years of age, it was designated an early-acquired word. "Current-acquired words" were those words that the youngest participants in the study were still learning. Their analyses showed that 5- and 8-year-old children were as sensitive to spoken errors in early-acquired words as were adults but that only 8-year-old children were as sensitive to spoken errors in "current" words as were adults. Another study used a gating task in which small pieces of a word were pronounced at first and listeners were exposed to additional pieces of the word sequentially until they could identify it (Metsala, 1997). Results of this study indicated that performance was most similar between children (9, 7, and 11 years of age) and adults for words that had high frequency and high neighborhood density. Furthermore, the study showed that older children had especially strong word-recognition performance on high frequency words from sparse phonological neighborhoods. Garlock, Walley, and Metsala (2001) examined the relationship of all three of these lexical characteristics with performance on two different spoken word recognition tasks, a gating task and a word repetition task, with children from preschool through second grade, and adults. The results of their study indicated that neighborhood density and AoA of the words were associated with performance on both tasks such that, for children, spoken word recognition was better for early acquired words and words from sparse phonological neighborhoods. Metsala, Stavrinos, and Walley (2009) replicated these results in a 1-year follow-up analysis on a subset of the sample used by Garlock et al. (2001).

Although the interactions between these lexical characteristics of words are complex and can differentially impact performance on spoken word recognition tasks, the results of the aforementioned studies can be explained within the context of LRM. Early-acquired words are more easily recognized (and spoken errors in these words are more easily detected) by younger children because as exposure to these and similar words increases a more detailed mental representation of these words develops (Brown & Watson, 1987; Walley & Flege, 1999). Older

children show better recognition performance on high frequency words from sparse neighborhoods because these words are the least susceptible to interference effects when evaluated with a gating task (Walley et al., 2003). With age, as the mental lexicon becomes increasingly refined and segmented, spoken word recognition for late-acquired words and words from dense phonological neighborhoods improves (Garlock et al., 2001). Taken together, these findings suggest that lexical restructuring does indeed occur as a child's vocabulary grows.

In the context of the LRM, it would be expected that phonological awareness performance for early-acquired words would be greater than that for later-acquired words because these words have had more time to undergo the requisite restructuring. Little research to date has examined the effects of AoA of phonological awareness items on phonological awareness performance, but one study has provided support for LRM when evaluating the effects of AoA on phonological awareness performance. Using a sample of 192 participants (64 preschool and kindergarten children, 64 first and second grade children, and 64 adults), Garlock et al. (2001) evaluated the effects of AoA on two separate phonological awareness tasks, an onset-recognition task and an initial phoneme deletion task. Overall, the results of the study indicated that phonological awareness performance was stronger for early-acquired words than for late-acquired words.

Based on the LRM, children's phonological awareness performance should be greater for high frequency words than for low frequency words, as these words are encountered more often in speech and text and, therefore, have had more opportunity to undergo segmental restructuring; however, few studies have examined the effects of word frequency on phonological awareness performance. Some studies have failed to yield results that support predictions of LRM when evaluating the effect of word frequency on phonological awareness skills. In one study, there was no relation between word frequency and participants' phonological awareness performance for any age group (Garlock et al., 2001). Roth, Troia, Worthington, and Handy (2006) demonstrated that on a rhyming task, children's performance was greater for low frequency words than for high frequency words, and they found that there was no effect of word frequency on phonological awareness performance measured with a segmenting task. In contrast to these results, results from other studies have supported predictions of LRM when examining the effects of word frequency on phonological awareness performance. In a sample of 194 second and fourth grade children, Hogan, Bowles, Catts, and Storkel (2011) demonstrated that

phonological awareness performance (assessed with a phoneme deletion task) was greater for high frequency words than for low frequency words. In the Roth et al. (2006) study, phonological awareness performance on a blending task was greater for high frequency words than for low frequency words.

Studies that have examined the effects of phonological neighborhood density on phonological awareness performance also have shown mixed results. According to LRM, phonological awareness performance should be greater for words from dense phonological neighborhoods than for words from sparse neighborhoods because words from dense neighborhoods have many similar “neighbor” words that necessitate differentiation of the lexicon. Some studies, however, have failed to find an effect of phonological neighborhood density on children’s phonological awareness performance (Garlock et al., 2001; Roth et al., 2006; Stadler, Watson, and Skahan, 2007). One study showed that children’s performance on a blending task was greater for words from sparse phonological neighborhoods than dense phonological neighborhoods (Roth et al., 2006). Foy and Mann (2009) demonstrated that 37 preschool children’s reaction times on phonological awareness measures were slower for words from dense onset neighborhoods than for words from sparse onset neighborhoods (words belonging to dense onset neighborhoods share their initial phoneme with at least 50% of their phonological neighbors, while words belonging to sparse onset neighborhoods share their initial phoneme with fewer than 50% of their neighbors). In contrast to the results of these studies, De Cara and Goswami (2003) reported that children with high vocabulary age performed better on phonological awareness items that used words from dense phonological neighborhoods than items that used words from sparse neighborhoods. Similarly, Roth et al. (2006) reported that children were more capable of producing rhymes for words from dense phonological neighborhoods than they were for words from sparse phonological neighborhoods. Other studies have also reported that phonological awareness performance, when assessed by a phoneme deletion task, is greater for words from dense phonological neighborhoods than for words from sparse phonological neighborhoods (Hogan et al., 2011; Ventura, Kolinsky, Fernandes, Querido, & Morais, 2007).

Because prior research has generated conflicting results and some previous studies were small (e.g., Foy & Mann, 2009; Ventura et al., 2007) or methodologically weak (e.g., De Cara & Goswami, 2003), more research is needed to determine the true relations between these lexical

characteristics of words and phonological awareness skills. It is important to note that all of the aforementioned studies, with the exception of Hogan et al., (2011), divided words into two groups according to whether they were high or low on one of the three lexical characteristics (AoA, word frequency, and neighborhood density) rather than treating each of the lexical characteristics as continuous variables. In addition, most of these studies were conducted on relatively small samples; only the studies by Hogan et al. (2011) and Garlock et al. (2001) exceeded one hundred participants. Furthermore, when examining the effects of vocabulary knowledge on phonological awareness, at least one study (De Cara & Goswami, 2003) used a median split of vocabulary knowledge to group children into either low or high vocabulary age based on their sample's performance on the British Picture Vocabulary Scales (Dunn, Dunn, Whetton, and Pintilie, 1982) rather than treating vocabulary knowledge as a continuous variable.

The study most similar to the present study is Hogan et al. (2011), although there are distinctions between Hogan et al. (2011) and this study. Hogan et al. (2011) evaluated the effects of word frequency and phonological neighborhood density on children's phonological awareness performance. They used a hierarchical logistic regression model in which phonological awareness items were nested within participants. For their analyses, they used a sample of 194 second and fourth grade children who were administered a phoneme deletion task. Their model included three predictors (i.e., neighborhood density, word frequency, and grade) and their interactions (e.g., the interaction between neighborhood density and word frequency, the interaction between neighborhood density, word frequency, and grade). The present study used a cross-classified logistic model, in which phonological awareness items were crossed with participants, as opposed to the hierarchical model used by Hogan et al. (2011) in which items were nested within participants. The samples used in this study consisted of younger children (children in preschool) than those used by Hogan et al. (2011) and were larger samples.

The effects of word frequency, AoA, neighborhood density, and phonotactic probability on phonological awareness performance were examined. To date, no known studies have examined the effect of phonotactic probability on children's phonological awareness performance or the LRM. Because phonological neighborhood density is a part of the LRM and is correlated with phonotactic probability, phonotactic probability was included in the current model. Higher frequencies of phonological segments or sequences of phonological segments within a language should necessitate the further refinement of one's mental lexicon in order to

differentiate words that include identical or similar phonological segments. In addition to examining the effects of these lexical characteristics on an elision task (a task similar to a phoneme deletion task that also requires participants to delete supra-phonemic parts of words), the effects of these lexical characteristics on phoneme (and supra-phonemic) blending performance were explored. Moreover, based on LRM, phonological awareness performance is dependent upon vocabulary development; thus, the interactions between child-level vocabulary knowledge and these item-level lexical characteristics on phonological awareness performance were examined. This study further contributes to our knowledge of the developmental origins of phonological awareness and the role that lexical restructuring plays in children's reading and language skill development.

Several hypotheses were evaluated in this study. First, it was predicted that as phonological neighborhood density of items increased, phonological awareness performance would increase. Second, it was predicted that phonological awareness performance would be greater for earlier-acquired words than for later-acquired words. Third, it was predicted that phonological awareness performance would be greater for high frequency words than for low frequency words. In addition, it was hypothesized that phonological awareness performance would increase as phonotactic probability increased. It was also hypothesized that each of these lexical characteristic variables would interact with both age and overall vocabulary knowledge of the participants, given that LRM states that as vocabulary knowledge increases, the mental lexicon becomes increasingly segmented and refined, which should impact the relations between the lexical characteristic variables and phonological awareness performance. Moreover, it was predicted that these relations would hold while controlling for overall cognitive ability.

CHAPTER TWO

METHODS

Participants

Two samples of preschool children from two studies that evaluated preschool curricula were used in this study. The data used were from children's initial assessments that occurred before exposure to substantially different preschool experiences as a result of the different curriculum conditions in the studies. Both studies were conducted in preschools serving primarily children from low-income families. Consequently, the majority of children in the samples had higher than average risk for later academic difficulties. Data collection took place at the beginning of the preschool year, before children were exposed to intervention curricula.

The first sample included 392 children from Florida who ranged in age from 33 to 64 months ($M = 52.17$, $SD = 5.95$). Males comprised 58.1% of the sample, and the majority of children in the sample (56.8%) were African American/Black, 33.3% were white, and the remainder of the sample were of other ethnicities. The second sample included 814 children from Los Angeles and Florida who ranged in age from 33 to 70 months ($M = 49.83$, $SD = 6.22$). Males comprised 52.7% of the sample, and the majority of the children in the sample were African American/Black (84.2%), 7.9% were white, 6.9% were Latino and the remainder of the sample were of other ethnicities.

Measures

Phonological awareness. Children completed the Blending and Elision subtests from the Preschool Comprehensive Test of Phonological and Print Processing (P-CTOPPP; Lonigan, Wagner, Torgesen, & Rashotte, 2002). The Blending subtest contains 21 items that require children to blend two components of words together to create a new word. Items included blending two words to form a compound word (e.g., blending "star-" and "-fish" to create "starfish"), blending syllables to form a word (e.g., blending "doc-" and "-tor" to create "doctor"), or blending individual phonemes to form a word (e.g., blending /f/ and "-ox" to create "fox"). Both multiple-choice and free-response items are included (9 multiple-choice, 12 free-response items). On the multiple-choice items, children are required to point to a picture of (or say) the word that is created after combining the two stimuli. On the free-response items,

children are required to say the word that is created as a result of blending the two stimuli. The Elision subtest contains 18 items that require children to eliminate parts of a word to form new words. Items included removing one word from a compound word (e.g., removing “snow” from “snowshoe” to create “shoe”), removing a syllable from a word (e.g., removing “-ture” from “fixture” to create “fix”), and removing a phoneme from a word (e.g., removing “-d” from “raid” to create “ray”). Both multiple-choice and free-response items are included (9 multiple-choice, 9 free-response items). On the multiple-choice items, children are required to point to a picture of (or say) the word that is remaining after removing part of the initial word. On the free-response items, children are required to say the word that is remaining after removing part of the initial word. Internal consistency reliability for each of these subscales is moderately high ($\alpha = .87$ for blending; $\alpha = .86$ for elision).

Oral language skills. Children in the first sample were administered the definitional and receptive vocabulary portions of the P-CTOPPP. In the definitional vocabulary portion of the measure, children are shown pictures and asked 2 questions about each picture (e.g., the first question may be “what is it?”, and the second question may be “what is it for?”). In the receptive vocabulary subscale, a child is shown four pictures, and asked to point to one of them. Thus, all items on the receptive vocabulary subscale are multiple-choice items and all items on the definitional vocabulary subscale are free-response items. Each of the vocabulary subscales contains 40 items. Responses are coded as either correct or incorrect. Internal consistency reliability for these subscales ranges from moderate to high ($\alpha = .89$ for receptive vocabulary; $\alpha = .98$ for definitional vocabulary). Children in the first sample also completed the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007). The PPVT-4 is a measure of receptive vocabulary, in which children are asked to point to one of four displayed pictures. Internal consistency reliability for the PPVT ranges from .94-.95 for the two forms. Participants in the second sample were administered the Preschool Language Scales, Fourth Edition (PLS-4; Zimmerman, Steiner, & Pond, 2002). The PLS-4 evaluates children’s receptive and expressive language skills. Internal consistency reliability for the PLS-4 ranges from moderate to high for children ages 3-5. (α s = .87-.94 for receptive language, .92-.95 for expressive language, and .94-.97 for the total score).

Cognitive ability. Children in the second sample completed three subtests from the Stanford-Binet Intelligence Scale, Fourth Edition (SB-IV; Thorndike, Hagen, & Sattler, 1986),

Pattern Analysis, Copying, and Bead Memory. This measure was used to account for overall cognitive ability when evaluating the impact of lexical characteristics of items and vocabulary knowledge on phonological awareness skills. Internal consistency reliability for the pattern analysis, copying, and bead memory subtests is moderately high ($\alpha = .85-.90$ for pattern matching, .88 for copying, and .87-.89 for bead memory).

Coding lexical characteristics. Each unique word on the Blending and Elision subtests was coded for phonological neighborhood density, word frequency, AoA, and phonotactic probability. The Elision subtest was broken up into stimulus and target words to see if this impacted the results. Elision stimulus words were the initial words spoken to children that require manipulation to form a new word by removing a part of the stimulus word. Elision target words were those words that children formed by removing a part of the stimulus word. Blending words were not divided into stimulus and target groups because there were multiple blending stimuli for each item, several of which were not words. The lexical characteristic values of the words on the phonological awareness portion of the P-CTOPPP are shown in Table 1. Word frequency values were obtained using the Irvine Phonotactic Online Dictionary, version 2.0 (IPhOD; Vaden, Halpin, & Hickok, 2009). This database gives the SUBTLEXus word frequency value, which is based on the number of times the word occurs in a corpus of 51 million words from subtitles of American films. These values were then z-scored. AoA norm values were obtained from a database of 3,000 monosyllabic words (Cortese & Khanna, 2008), norms from Gilhooly and Logie (1980) in the MRC Psycholinguistic Database (Coltheart, 1981), and the lexical development norms (Dale & Fenson, 1996). AoA norms for each of these databases were constructed by having adults rate the age at which they or their children acquired certain words. Using Spearman rank-order correlations, these measures were generally correlated with one another in the data used for this study. AoA values from Cortese & Khanna (2008) were significantly correlated with both Gilhooly and Logie (1980) ($r_s = .70$) and the lexical development norms (Dale & Fenson, 1996) ($r_s = .55$); however, AoA norms from Gilhooly and Logie (1980) were not significantly correlated with values from the lexical development norms (Dale & Fenson, 1996) ($r_s = .29$). Because these databases contained AoA values on different scales, z-scores were computed. When AoA values for compound words were unavailable, these values were computed by averaging the AoA values of the individual words within the compound word. 43 of 53 AoA values used for words on the P-CTOPPP came from the Cortese

& Khanna (2008) database, 8 came from the lexical development norms (Dale & Fenson, 1996), and 2 came from Gilhooly and Logie (1980). AoA values for two bi-syllabic words on the blending subscale of the P-CTOPPP (Lonigan et al., 2002) were unavailable. Furthermore, AoA values were unavailable for two of the elision stimulus words.

Phonological neighborhood density and phonotactic probability values were calculated using the Child Mental Lexicon Calculator (CMLC; Storkel & Hoover, 2010). This calculator used a corpus of 4,832 words from 2 databases of words spoken by kindergarten and first-grade children to compute values for phonological neighborhood density and phonotactic probability. Phonological neighborhood density simply represented the number of words in the corpus that differ from a target word by only one phoneme. The CMLC computed values for each phoneme as well as each biphone segment within each word in the corpus. In addition, the sum of the values of each phoneme and the sum of the values of the bi-phoneme segments were computed. Then, an average phoneme and bi-phone value was obtained by dividing the previously mentioned sums by the number of phonemes or bi-phones in the word, respectively. These averages were chosen for use in the present study because they represent the words' phonotactic probability values rather than the value of the individual phonemic and bi-phonemic components of the words. Z-scores were computed for both phonotactic probability and neighborhood density, as these variables are often correlated with word length. Means and standard deviations generated by Storkel (2004) from the Hoosier Mental Lexicon (Nusbaum, Pisoni, & Davis, 1984) were used to compute z-scores that were independent of word length.

Data Analysis

Data analysis for both samples employed a cross-classified generalized linear model that was fit to the data. In these data, items were crossed with participants, such that every participant received every phonological awareness item. The cross-classified model, as opposed to a hierarchical nested model, allowed for the direct testing of the proposed hypotheses. Item-level variables (phonological neighborhood density, phonotactic probability, AoA, and word frequency) were used to predict the likelihood of children correctly responding to phonological awareness items. Then, in the second sample, overall cognitive ability was entered to gain estimates of the effects of these lexical characteristics on children's phonological awareness skills while controlling for intelligence, as assessed by the SB-IV. The cross-classified model also allowed for the creation of interaction terms between the child-level variables (age and

vocabulary knowledge) and the item-level variables (phonological neighborhood density, word frequency, age of acquisition, and phonotactic probability) to determine the effects of child-level variables on the relationship between these lexical characteristics and phonological awareness skills. This would not have been possible if the data were analyzed in a hierarchical fashion, as in a nested model an interaction term cannot be created between level one and level two variables.

CHAPTER THREE

RESULTS

Descriptive Statistics

Descriptive statistics for item-level variables are reported in Table 2. Children from both samples scored below the mean on the oral language assessments (Sample 1: $M = 85.91$, $SD = 16.08$; Sample 2: $M = 91.31$, $SD = 17.71$). Children's mean overall non-verbal cognitive ability (averaged across the 3 subtests of the SB-IV) was 43.10 ($SD = 22.92$). Two sets of analyses were conducted with each sample. The first analysis included words from the blending subtest of the P-CTOPPP along with the elision stimulus words from the P-CTOPPP. Elision stimulus words were the initial words spoken to children that required manipulation to form a new word by removing a part of the stimulus word. The second analysis included words from the blending subtest of the P-CTOPPP along with the elision target words from the P-CTOPPP. Elision target words were those words that children formed by removing a part of the stimulus word. Blending words were not divided into stimulus and target groups because there were multiple blending stimuli for each item, several of which were not words.

Model Descriptions

For both samples, analyses involved five models, each representing a more conservative test of the effects of the item- and child-level predictors than the previous. The first analysis included all of the separate first-order models that tested the univariate effects of each of the child- and item-level predictor variables. The second model tested the multivariate effects of the item-level lexical-characteristic variables. For analyses that included elision stimulus words, phonological neighborhood density, individual phoneme probability, and biphone probability were all significantly correlated with each other (r for phonological neighborhood density and individual phoneme probability = .47, $p < .01$; r for phonological neighborhood density and biphone probability = .82, $p < .001$; r for individual phoneme and biphone probabilities = .70, $p < .001$). To avoid effects of multicollinearity, the second model was fit hierarchically. The initial step included phonological neighborhood density; individual phoneme and biphone probabilities were added in the second and third steps, respectively. Because of an effect of multicollinearity in both samples, as evidenced by a non-significant odds ratio for individual phoneme probability when biphone probability was included in the model, all subsequent models excluded biphone

probability. For analyses that included elision target words, both phonological neighborhood density and individual phoneme probability were significantly correlated with biphone probability (r for phonological neighborhood density and biphone probability = .56, $p < .001$; r for individual phoneme and biphone probabilities = .62, $p < .001$). To avoid multicollinearity, these models also were fit hierarchically in two steps in which the first step included all lexical characteristic variables except biphone probability, which was added in the second step. For analyses that involved elision target words, there was no effect of multicollinearity for either the first or second sample. The third model tested the main effect of item type (i.e., blending or elision) as well as the interactions between item type and the lexical characteristic predictor variables that were significant in the prior models. The fourth model included the main effects of the child-level variables. The first sample included chronological age as well as the PPVT, and the second sample included chronological age, the PLS-4, and a measure of overall cognitive ability. The fifth model tested the interactions between significant child- and item-level predictor variables.

Sample 1: Elision Stimulus Words Analyses

Results for analyses that included blending words and the elision stimulus words are reported in Table 3. Significant univariate effects of age of acquisition (AoA), item type, chronological age, and oral language skills were detected. When the multivariate effects of item-level predictors were tested, AoA, word frequency, and individual phoneme probability were all significant unique predictors of children's phonological awareness skills; however, individual phoneme probability did not uniquely predict children's phonological awareness skills when the main effects of item type and the interactions between item type and the lexical characteristic variables were included in the model. In addition, the main effect of item type was not significant in the multivariate effects of the item-level predictor variables were examined. AoA and word frequency were both negative predictors of children's phonological awareness skills, whereas individual phoneme probability was a positive predictor of children's phonological awareness skills. Children were more likely to respond correctly to blending items than elision items. Both child-level covariates were significant unique predictors of children's phonological awareness skills. There were significant interactions between children's oral language skills and both AoA and word frequency. Furthermore, when child-level-by-item-level interaction terms were included in the model, item type significantly predicted children's phonological awareness skills.

To probe these interactions, the simple effects of AoA and word frequency were examined assuming all children were either one standard deviation above or below the mean of oral language. These interactions are shown in Figures 1 and 2, respectively. At high levels of oral language, the relation between the AoA of words and children's phonological awareness skills was significant ($OR = .40, p < .01$). Similarly, the simple effect of AoA was significant at low levels of oral language ($OR = .34, p < .001$). Therefore, the negative effect of AoA was more severe for children with poor oral language skills than for children with strong oral language skills. At high levels of oral language, the relation between word frequency and children's phonological awareness skills was significant ($OR = .62, p < .05$); however, at low levels of oral language, the relation between word frequency and children's phonological awareness skills was not significant ($OR = .74, p = .19$). In contrast to the interaction between AoA and oral language skills, the negative effect of word frequency on children's phonological awareness skills was greater for children with strong oral language skills than for children with poor oral language skills.

Sample 1: Elision Target Words Analyses

Results for analyses that included blending words and the elision target words are shown in Table 4. AoA, word frequency, item type, chronological age, and oral language were all significant univariate predictors of children's phonological awareness skills. When the multivariate effects of the lexical characteristic variables were examined, individual phoneme probability was also uniquely predictive of children's phonological awareness skills. The main effect of item type was not significant when the multivariate effects of the item-level predictors were examined. Children's chronological age and oral language skills were significant predictors of children's phonological awareness skills. There was a significant interaction between word frequency and chronological age as well as between AoA and oral language skills.

To probe the nature of these interactions, the simple effects of word frequency and age of acquisition were tested assuming all children were either one standard deviation above or below the mean on chronological age and oral language skills, respectively. These interactions are shown in Figures 3 and 4, respectively. At high levels of chronological age, the simple effect of word frequency was marginally significant ($OR = .67, p = .08$); however, at low levels of chronological age, the simple effect of word frequency on children's phonological awareness skills was significant ($OR = .55, p < .05$). Therefore, the negative effect of word frequency on

children's phonological awareness skills was larger for younger children than for older children. Consistent with results from the analyses using the elision stimulus words, the relation between AoA and phonological awareness skills was significant at both high and low levels of oral language skills (for high oral language $OR = .46, p < .01$; for low oral language $OR = .38, p < .001$). This interaction operated in the same direction as the interaction between AoA and oral language skills for the elision stimulus word analysis. That is, the negative effect of AoA on children's phonological awareness skills was larger for children with poor oral language skills than it was for children with strong oral language skills.

Sample 2: Elision Stimulus Words Analyses

Results for analyses that included blending items and the elision stimulus words are shown in Table 5. AoA, item type, chronological age, and oral language skills were significant univariate predictors of children's phonological awareness skills. When the multivariate effects of the lexical characteristic variables were examined, individual phoneme probability, AoA, and word frequency were significant unique predictors of children's phonological awareness skills; however, individual phoneme probability was not uniquely predictive of children's phonological awareness skills when the main effect of item type and the interactions between item type and the lexical characteristic variables were included in the model. Furthermore, the main effect of item type was no longer statistically significant when the multivariate effects were examined. Children's chronological age and oral language skills remained significant predictors of their phonological awareness skills when multivariate effects were tested.

There was a significant interaction between AoA and chronological age. To probe the effects of this interaction, the simple effects of AoA were tested assuming all children were either one standard deviation above or below the mean on chronological age. This interaction is shown in Figure 5. At both high and low levels of chronological age the relation between AoA and children's phonological awareness skills was statistically significant (for high chronological age $OR = .37, p < .01$; for low chronological age $OR = .33, p < .001$). The negative effect of AoA on children's phonological awareness skills was larger for younger children than for older children.

Sample 2: Elision Target Words Analyses

Results for analyses that included blending and elision target words are shown in Table 6. Age of acquisition, word frequency, item type, chronological age, and oral language were all

significant univariate predictors of children's phonological awareness skills. When the multivariate effects of the lexical characteristic variables were examined, individual phoneme probability was an additional unique predictor of children's phonological awareness skills. The main effect of item type was no longer statistically significant when multivariate effects were examined. The multivariate effects of chronological age and oral language skills were both statistically significant. All significant main effects were operating in a direction consistent with the findings of the other analyses.

There was a significant interaction between AoA and chronological age. To probe this interaction, the simple effects of AoA were tested assuming all children were either one standard deviation above or below the mean of chronological age. This interaction is shown in Figure 6. The simple effects of AoA were significant at both high and low levels of chronological age (for high chronological age $OR = .41, p < .01$; for low chronological age $OR = .38, p < .001$). Consistent with results from the elision stimulus analysis for Sample 2, the negative effect of AoA was larger for younger children than for older children.

CHAPTER FOUR

DISCUSSION

This study evaluated the LRM and the impact that various lexical characteristics of words have on preschool children's phonological awareness skills. The central hypothesis about how lexical restructuring improves children's phonological awareness skills in the context of the LRM is that as children's vocabularies increase, their mental representations of words shift from holistic to increasingly segmented representations. Improvement in phonological awareness skills occurs because the shift in children's mental representations of words allows children to access the individual sound segments within words (e.g., phonemes) that can be manipulated. This effect occurs locally, only for the individual words that a child knows. The LRM posits that when children learn new words, the lexical characteristics of these words should play a role in dictating how much segmental restructuring occurs, which will lead to an increase in phonological awareness skills.

In this study, the effects of four lexical characteristics of words were examined: phonological neighborhood density, phonotactic probability, AoA, and word frequency. It was hypothesized that each of these characteristics would affect children's performance on a phonological awareness assessment, such that children would have a greater likelihood of responding correctly to phonological awareness items that had high neighborhood density, phonotactic probability, and word frequency values than to phonological awareness items with low values on these lexical characteristics. Furthermore, it was hypothesized that children would have a greater likelihood of correctly responding to phonological awareness items with low AoA values than items with high AoA values. Results consistent with these hypotheses were obtained for phonotactic probability and AoA; however, results consistent with the hypotheses were not obtained for word frequency or neighborhood density. The results for the main effects of the lexical characteristics of phonological awareness items were consistent across two independent samples. The findings of this study provided partial support for the LRM.

Phoneme probability. As the average individual phoneme probability of words increased, children's phonological awareness skills increased. That is, children were better able to manipulate the sounds that are more likely to occur in spoken language. Results did depend, in part, on the unit of analysis: for analyses that included both blending and elision stimulus items,

the effect of individual phoneme probability became non-significant when tested in the context of the effect of item type; however, for analyses that included both blending and elision target items, the main effect of individual phoneme probability remained significant when tested in the context of the effect of item type. Individual phoneme probability should have a greater impact on children's phonological awareness skills for words with high average individual phoneme probability values than words with low average individual phoneme probability values. Words with high average individual phoneme probability undergo lexical restructuring more than words with low average individual phoneme probability because the sounds of words with high average individual phoneme probability have a higher likelihood of occurrence in English. A higher likelihood of occurrence leads to increased exposure to these sounds, and children will be more capable of distinguishing these sounds from one another than sounds with a low likelihood of occurrence. Results were consistent with this expectation, as the individual phoneme probability of the elision target words (mean of average individual phoneme probability = .65) had a greater impact on children's phonological awareness skills than did the individual phoneme probability of the elision stimulus words (mean of average individual phoneme probability = .38) in both samples.

The findings of this study are consistent with the results of other studies. Although no known prior studies have examined the effect of phonotactic probability on children's phonological awareness skills, studies have examined the impact of phonotactic probability on children's phonological memory. Wagner and Torgesen (1987) argued that phonological awareness and phonological memory are related tasks with at least some degree of overlap. Therefore, if phonotactic probability is a significant predictor of phonological awareness skills, it should also be a significant predictor of children's phonological memory. In fact, children do perform better on non-word repetition tasks (a phonological memory task) for non-words that have high phonotactic probability values (e.g., Edwards, Beckman, & Munson, 2004; Vitevitch & Luce, 1998; Vitevitch & Luce, 2005). In combination with results of this study, these findings provide strong evidence for the role of phonotactic probability on the development of phonological awareness in the context of the LRM.

Age of acquisition. As the AoA of phonological awareness items increased, children's phonological awareness skills decreased. Because early-acquired words have had more time than late-acquired words to undergo restructuring in children's mental lexicons, children's

phonological awareness skills are greater for early-acquired words than for late-acquired words. This finding was consistent across samples in this study and with the findings of previous research (Garlock et al., 2001), providing strong support for the LRM.

Word frequency. Results for word frequency were not consistent with predictions derived from the LRM and suggest the potential need for a reconceptualization of how word frequency may impact children's performance on phonological awareness assessments. The effect of word frequency was opposite the predicted effect. Specifically, children were less likely to respond correctly to words with higher frequencies than they were to words with low frequencies. Prior research has found mixed results for the impact of word frequency on children's phonological awareness skills. Because the relation for word frequency and children's phonological awareness skills obtained in this study was not in the direction hypothesized and prior research has demonstrated mixed results, the characteristics of prior studies were examined and compared to characteristics of this study. The study most similar to this study in method, although not in the age of participants (i.e., preschool versus elementary school age children), is that of Hogan and colleagues (2011). Their study also involved an elision measure, did not manipulate items based on their lexical characteristics, and used hierarchical logistic models to estimate the impact of the lexical characteristics of words on children's phonological awareness skills. In contrast to the results of this study, they reported that children were more likely to respond correctly to high frequency words than to low frequency words on the PA measure.

Other studies have dichotomized the word frequency values of items when predicting children's phonological awareness skills, such that items were considered as either high frequency or low frequency. One study found that on a rhyming task, children's phonological awareness skills were greater for low-frequency words but on a blending task children's phonological awareness skills were greater for high-frequency words (Roth et al., 2006). The study conducted by Roth and colleagues (2006) was similar to the present study because the sample included four- to six-year-old children, and items tested were not chosen based on their lexical characteristics. Therefore, similar results between the two studies were expected, although only their findings when phonological awareness skills were assessed using a rhyming task were similar to the findings of this study. Thus, it seems that the unit of manipulation within phonological awareness items is particularly important when examining the effects of word frequency on children's phonological awareness skills. Rhyming tasks often require producing

words that differ from the stimulus word by more than one phoneme, and the phonological awareness measure used in this study mostly required manipulation of words at the supra-phonemic level. Conversely, the blending measure used by Roth et al. (2006) required children to blend individual phonemes together to produce whole words. Perhaps the frequency of phonological awareness items has a greater positive impact on children's phonological awareness skills when children are required to manipulate individual phonemes, as children's lexicons need to be more segmented to manipulate individual phonemes than supra-phonemic units of sound. Another study that included preschool and kindergarten age children tested phonological awareness items that were chosen based on word frequency. In that study, no effect of word frequency was reported when words were dichotomized as high and low frequency words (Garlock et al., 2001).

Another characteristic of prior studies, the source of the word frequency values, was examined and compared to this study. Both Garlock et al. (2001) and Hogan et al. (2011) used word frequency values from Kucera and Francis (1967), which was developed from approximately one million words from five hundred American English texts published in 1961. Roth et al. (2006) computed word frequency values from Carroll, Davies, and Richman (1971), which used approximately five million words from a variety of texts published in English. In contrast, word frequency in this study was estimated based on SUBTLEXus word frequency values, a more recent database (from 2008) of word frequency values computed from 51 million words from subtitles of American films. Brysbaert and New (2009) demonstrated that SUBTLEXus provides a better index of frequency than does Kucera and Francis (1967). Thus, the results of the present study may be a better estimate of the true effects of word frequency on children's phonological awareness skills. It is unknown how frequently preschool children watch subtitled American films or read American texts published in 1961; however, more valid results for word frequency might be obtained if a measure of word frequency that came from spoken language to which preschool children are often exposed was used.

Follow-up analyses were conducted using word frequency estimates from Kucera and Francis (1967) to see if this changed the results of this study. For analyses that included both blending and elision stimulus items, the correlation between the two sets of word frequency values was .80. For both samples, results obtained when using Kucera and Francis (1967) word frequency values indicated that word frequency was negatively related to children's phonological

awareness skills (Sample 1 OR = .45; Sample 2 OR = .42), which was consistent with results obtained from SUBTLEXus word frequency values. For analyses that included both blending and elision target items, the correlation between the two sets of word frequency values was .90. For both samples, results obtained when using Kucera and Francis (1967) word frequency values indicated that word frequency was negatively related to children's phonological awareness skills (Sample 1 OR = .47; Sample 2 OR = .41), which was also consistent with results obtained from SUBTLEXus word frequency values. Consequently, there are no clear patterns of study features that can help explain the mixed findings across studies. Perhaps this study provides a better estimate of the true effect of word frequency on preschool children's phonological awareness skills because this study used larger samples than previous studies; the results replicated across the two independent samples; word frequency was not dichotomized, and a better index of word frequency was used.

Neighborhood density. Neighborhood density also was not a significant predictor of children's phonological awareness skills in any analyses. Based on the LRM, children should be more likely to respond correctly to phonological awareness items that come from dense phonological neighborhoods than to items that come from sparse phonological neighborhoods. This is because words that have many neighbor words that differ by only one phoneme necessitate restructuring in a child's mental lexicon so that the child can distinguish those words from one another. Prior research has used both measures of phonological awareness on which words were chosen to reflect specific neighborhood densities, such that half of the items came from sparse neighborhoods and half of the items came from dense neighborhoods (e.g., Garlock et al., 2001) as well as measures of phonological awareness on which words were not chosen to reflect specific lexical characteristics (e.g., Hogan et al., 2011). Previous studies have shown inconsistent results within types of phonological awareness assessments used. For example, some studies that have used phonological awareness assessments on which words were chosen based on neighborhood density have found no effect of neighborhood density on phonological awareness skills (e.g., Stadler et al., 2007), whereas others have found significant effects of neighborhood density (Foy & Mann, 2009). Similarly, some studies that used measures on which words were not chosen based on neighborhood density have found mixed results of neighborhood density depending on the type of phonological awareness assessment used (Roth et al., 2006), and others have found a positive effect of neighborhood density (Hogan et al., 2011).

on children's phonological awareness skills. All of these studies--with the exception of Hogan et al. (2011)--examined the relation between neighborhood density and phonological awareness skills among preschool children.

The absence of an effect of neighborhood density on children's phonological awareness skills in the present study could be an artifact of the words on the P-CTOPPP. Out of the 39 blending and elision stimulus items, 12 items had no neighbor words that differed by only one phoneme. Out of the 39 blending and elision target items, 9 items had no neighbor words that differed by only one phoneme. Follow-up analyses were conducted without items that were at the floor of the neighborhood density scale. For all analyses, the effect of neighborhood density remained non-significant when these items were removed. This finding rules out the explanation that the non-significant finding of neighborhood density in this study was an artifact of the words on the P-CTOPPP. Because elision stimulus items require children to remove parts of words to form new words, the elision stimulus words were longer than their corresponding target words, and phonological neighborhood density is correlated with word length (Storkel, 2004). Because the phonological awareness assessment was not developed specifically for this study, it was not possible to manipulate items based on neighborhood density values. Perhaps an experimental measure of phonological awareness in which items were selected based on their neighborhood density values would provide a better estimate of the impact of neighborhood density on children's phonological awareness skills because researchers can ensure that their measure encompasses words that have varying levels of neighborhood density. It should be noted that although Hogan et al. (2011) did not use an experimental measure of phonological awareness, their measure did not yield the same floor effects on neighborhood density that the measure used in the present study did. However, because prior research that has used measures of phonological awareness in which words were chosen to reflect specific neighborhood densities has demonstrated mixed results, more research is needed to replicate these findings and determine the true impact of neighborhood density on children's phonological awareness skills.

To further categorize prior studies and compare them with this study, the unit of phonological analysis used in each study was examined. In this study, the P-CTOPPP mostly requires children to manipulate supra-phonemic components of words (e.g., syllables, individual words within compound words). Four prior studies used at least one measure of phonological awareness that required children to manipulate sounds at the level of the individual phoneme

(Foy & Mann, 2009; Garlock et al., 2001; Hogan et al., 2011; Roth et al., 2006). All of these studies—with the exception of Roth et al. (2006)—found significant, positive effects of neighborhood density on children’s phonological awareness skills. Two studies used rhyming measures to assess children’s phonological awareness skills (Roth et al., 2006; Stadler et al., 2007), which often require the manipulation of more than one phoneme. One study found significant, positive effects of neighborhood density on children’s performance on a rhyming task (Roth et al., 2006), while the other found no effect of neighborhood density on children’s performance on a rhyming task (Stadler et al., 2007). Perhaps because neighborhood density is a measure of how many words differ from the target word by only one phoneme, phonological awareness measures that focus on the manipulation of individual phonemes can help provide a better indication of how neighborhood density impacts children’s phonological awareness skills than a measure that requires supra-phonemic manipulation.

It might be useful to revise the LRM, replacing phonological neighborhood density with phonotactic probability. Phonotactic probability may be a better indicator of how phonological similarity between words and the probability of sounds occurring in a given language necessitates lexical restructuring than is phonological neighborhood density. Words can have phonological neighborhood density values of 0 because it is possible that a word (especially a longer word) has no neighbors that differ by only one phoneme. Conversely, it is impossible for the phonotactic probability values of words to reach zero because every phoneme in the English language has a non-zero probability of occurrence. Phonological awareness tasks require children to manipulate the sounds of words that they hear to produce a new word. If lexical restructuring is only necessitated by words a child learns, neighborhood density would most likely have a greater impact on children’s phonological awareness skills than phonotactic probability. However, because children hear continuous streams of speech rather than individual words, it seems likely that children must take into account more factors than just how many neighbors a word has. For instance, there are many sounds in a stream of speech, and children will become more familiar with sounds that are more likely to occur in the language they hear every day. Subsequently, children are more likely respond correctly to phonological awareness items that contain many sounds that have a high probability of occurrence.

Child characteristics. In addition to these lexical characteristics of words, the LRM predicts that children’s oral language skills, ages, and general cognitive abilities will impact their

phonological awareness skills. Across both samples in this study, main effects of age and vocabulary knowledge emerged, as predicted by the LRM (i.e., increases in children's vocabulary knowledge necessitate lexical restructuring so that children can differentiate between phonologically similar words in their mental lexicon). Children's vocabulary knowledge appears to be more important for the development of phonological awareness skills than their general cognitive abilities inasmuch as the measure of general cognitive abilities did not predict phonological awareness skills in this study, although vocabulary knowledge did.

It was hypothesized that the four lexical characteristic variables examined in this study (i.e., neighborhood density, phonotactic probability, AoA, and word frequency) would interact with children's ages and vocabulary knowledge. Based on the LRM, it was expected that AoA and word frequency would have a greater impact on the phonological awareness skills of younger children and children with less vocabulary knowledge, and phonotactic probability and neighborhood density would have a greater impact on the phonological awareness skills of older children and children with more vocabulary knowledge. Results consistent with this hypothesis were obtained for AoA but only partially for word frequency.

AoA interacted with children's ages in two of the four analyses; however, the effect sizes of the interaction terms were small. AoA interacted with children's ages for children in Sample 2 but not Sample 1. The effect of AoA on children's phonological awareness skills was greater for younger children than for older children. This finding is consistent with what was expected in the context of the LRM. Because younger children have been exposed to fewer words in general than older children, the AoA of words is more likely to negatively impact their phonological awareness skills. Younger children are less likely to have been exposed to late-acquired words than older children, and because lexical restructuring occurs locally, exposure to these words is a prerequisite for lexical restructuring and the subsequent improvement in phonological awareness skills.

For children in Sample 1, AoA interacted with children's oral language skills. As with children's ages, the negative effect of AoA was more severe for children with low oral language skills than for children with high oral language skills. Older children and children with greater oral language skills, on average, will be more familiar with late-acquired words than younger children and children with lower oral language skills. Therefore, the AoA of words will not have as severe a negative effect on older children and children with strong oral language skills

because the lexicons of older children or children with better language skills are more likely to have undergone lexical restructuring. The use of different measures of oral language skills across samples can help explain why the interaction between children's oral language skills and the AoA of phonological awareness items did not replicate across samples. Children in Sample 1 completed the PPVT, a measure of receptive vocabulary, and children in Sample 2 completed the PLS, a measure of oral language skills beyond vocabulary. The LRM posits that children's vocabulary knowledge will have a direct impact on their phonological awareness skills. Thus, a simple receptive vocabulary measure may be a better indicator of relevant oral language skills when evaluating the LRM than a measure of oral language skills that assesses other oral language skills in addition to vocabulary.

Word frequency interacted with children's ages for children in Sample 1 when the effects of elision target words were examined. There was a significant negative effect of word frequency on the phonological awareness skills of younger children, but not older children. This is contrary to what was predicted, that younger children would be more likely to respond correctly to phonological awareness items that contained high frequency words than to items that contained low frequency words. Because younger children would be exposed to high frequency words more often than low frequency words, these words should have had more opportunity to undergo lexical restructuring; however, this is not what the results indicated.

The interaction between word frequency and children's oral language skills was significant for children in Sample 1 when the effects of elision stimulus words were examined. In contrast to the interaction between word frequency and children's ages, there was a negative effect of word frequency for children with stronger oral language skills but not for children with weaker oral language skills. This is contrary to what was predicted in the context of the LRM. Based on the LRM, children's phonological awareness skills should increase as the frequency of the words increases. Although the finding that word frequency did not negatively impact the phonological awareness skills of children with poor oral language skills is consistent with the LRM, the negative impact of word frequency on phonological awareness should not become more severe as children's oral language skills increase. Word frequency should be a positive predictor of children's phonological awareness skills across the range of oral language skills unless children's oral language skills reach a level at which the difference in exposure to high

and low frequency words is negligible, at which point there should be no effect of word frequency on phonological awareness.

Limitations and Future Research

Despite some of this study's strengths, such as the large sample sizes and replication across two independent samples (with the exception of the interactions), this study has several limitations. First, the phonological awareness assessment completed by children was not one in which items were selected based on their lexical characteristics. Specifically, this was an issue for many items on neighborhood density and AoA, as many items had zero neighbor words that differed by only one phoneme, and AoA estimates were unavailable for several words. An assessment in which items are manipulated on these variables can ensure that these issues do not arise. Second, word frequency estimates were not obtained from sources to which preschool children are necessarily frequently exposed. A database of word frequency values could be developed that ensures frequency estimates of words are age-appropriate and come from spoken language, rather than text. Using age-appropriate word frequency estimates would help clarify the impact of the frequency of words on children's phonological awareness skills. Finally, the generalizability of the results may be limited because of the demographics of the two samples. Children were recruited from Head Start centers, and consequently represent a low-income sample of children. Furthermore, African-American children were over-represented in both of the samples.

Summary and Conclusions

The results of this study help advance knowledge about how phonological awareness skills develop in preschool children and what kinds of characteristics of words impact the development of children's phonological awareness skills. The findings of this study and the findings of other studies indicate that there is some need to revise certain aspects of the LRM. Differences in methods used in this study and prior studies can help clarify conflicting findings in previous research. The impact of word frequency may differ for different phonological awareness assessments, different measures of word frequency, and different age groups of children. Findings for word frequency and the finding that phonotactic probability may be a better indicator of phonological similarity to other words than neighborhood density suggest a need for a reconceptualization of the LRM; however, this study reaffirms the predictions made

by the LRM about how the AoA and phonotactic probability of words impacts children's phonological awareness development.

According to the LRM, children's developing phonological awareness skills should be shaped by various lexical characteristics of words. In general, the results of this study indicated that phonotactic probability, AoA, and word frequency had a significant impact on the phonological awareness skills of preschool children. Based on the results of this study, phonotactic probability appears to be a better indicator of the phonological similarity between words than phonological neighborhood density. AoA is an important predictor of children's phonological awareness skills as well, but AoA is more important for younger children than for older children. This study used a different measure of word frequency than previous studies, and found that preschool children's phonological awareness skills decreased as the frequency of the words increased, indicating that the impact of word frequency in the context of the LRM may need to be re-conceptualized; however, the relation between word frequency and children's phonological awareness skills was only significant for younger children and children with strong oral language skills. An important finding of this study is that these results, in general, replicated across samples, measures of oral language, and while controlling for children's overall cognitive ability; however, although the main effects of child and item level predictors replicated across samples, the interactions between these predictors did not. This study further advances the knowledge of the developmental origins of phonological awareness, an important predictor of children's future reading skills, as well as what factors contribute to the development of phonological awareness in young children.

APPENDIX

TABLES

Table 1.

Values of lexical characteristics for elision and blending items of the P-CTOPPP

Word	Item Type	Neighborhood Density	Phonotactic Probability (individual phonemes)	Phonotactic Probability (biphoneme segments)	Age of Acquisition	Word Frequency
Hotdog	Blending	-.62	-.94	-1.30	-.90	1.32
Starfish	Blending	-.46	-.71	-.14	.09	1.59
Doorknob	Blending	-.62	-.80	-1.42		1.94
Basket	Blending	.55	2.12	.48	.76	2.83
Circle	Blending	-.62	1.43	-.51	-.45	3.04
Cookie	Blending	-.41	.24	-1.14	-1.56	2.93
Bear	Blending	.92	1.36	.90	-.24	3.47
Cat	Blending	1.98	2.08	2.33	-1.44	3.53
Goat	Blending	.92	.13	-.08	-.39	2.73
Bathtub	Blending	-.62	.55	-.41	-.01	2.49
Airplane	Blending	-.62	.07	-1.16	-.79	2.75
Raincoat	Blending	-.62	.76	-1.05	.09	1.93
Doctor	Blending	-.62	1.39	-.49	.25	4.13
Rabbit	Blending	-.40	.87	-.61	-.58	3.03
Spider	Blending	-.62	.25	-.65		2.71
Fox	Blending	.25	.45	-.22	-.39	3.04
Soak	Blending	.57	1.41	-.13	1.10	2.25
Cap	Blending	1.39	1.50	2.12	.06	2.98
Hat	Blending	1.86	1.01	.98	-.69	3.52
Bike	Blending	.09	.09	-.13	-.39	3.12
Fish	Blending	-.62	.32	.00	-.54	3.63

Table 1 – continued

Word	Item Type	Neighborhood Density	Phonotactic Probability (individual phonemes)	Phonotactic Probability (biphoneme segments)	Age of Acquisition	Word Frequency
Seesaw	Stimulus	-1.08	.81	-.81	-1.18	1.36
Snowshoe	Stimulus	-.91	-.45	-1.40	-1.02	.48
Sunflower	Stimulus	-.46	-.32	-.91	-.67	1.54
Candy	Stimulus	4.19	1.95	2.52	-.44	3.26
Battle	Stimulus	-.40	1.50	.72		3.33
Dresser	Stimulus	-.91	.95	-.08	.12	2.26
Shoelace	Stimulus	-.14	-.74	-.62	-.23	3.93
Tease	Stimulus	-.26	-.77	-.65	.35	2.46
Lamp	Stimulus	.91	.24	.81	-.38	2.82
Shoot	Stimulus	-.91	-.93	-1.32	-.16	1.59
Playground	Stimulus	-.46	-.90	-1.30	1.18	2.42
Driveway	Stimulus	-.62	-1.07	-.84	-.23	2.54
Airport	Stimulus	-.62	.22	-1.52	.65	3.29
Dumpster	Stimulus	-.46	.66	.17		2.31
Fixture	Stimulus	-.62	.38	-.48	.00	1.52
Heat	Stimulus	.80	.05	-.46	-.38	3.31
Team	Stimulus	.09	-.18	-.69	-.08	3.88
Raid	Stimulus	1.27	-.35	-.12	2.69	2.64
Saw	Target	-.61	3.00	.25	-.09	4.31
Shoe	Target	.26	-.86	-.46	-.69	3.19
Sun	Target	-1.09	2.13	1.90	-.99	3.55
Can	Target	1.98	2.68	3.96	-.54	5.43
Bat	Target	2.57	1.24	1.12	.06	3.02
Dress	Target	.47	.60	.31	-.39	3.65
Shoe	Target	.26	-.86	-.46	-.69	3.19

Table 1 – continued

Word	Item Type	Neighborhood Density	Phonotactic Probability (individual phonemes)	Phonotactic Probability (biphoneme segments)	Age of Acquisition	Word Frequency
Tea	Target	1.26	.45	-.11	.50	3.48
Lamb	Target	1.04	.57	.67	-.09	2.73
Shoe	Target	.26	-.86	-.46	-.69	3.19
Play	Target	-.26	.17	.52	-.84	4.26
Drive	Target	.47	-.31	-.07	.65	3.89
Port	Target	-1.08	1.52	-.23	2.90	2.87
Dump	Target	-1.08	-.12	.94	1.70	3.17
Fix	Target	.69	1.11	.78	.35	3.65
He	Target	1.26	.30	-.07	-1.14	5.59
Tea	Target	1.26	.45	-.11	.50	3.48
Ray	Target	1.88	.54	.57	1.55	3.70

Table 2.

Descriptive statistics for item level variables

Predictor	Blending	Elision Stimulus	Elision Target
	Mean (SD)	Mean (SD)	Mean (SD)
Neighborhood Density	.08 (.88)	.03 (1.05)	.29 (.99)
IPP	.65 (.87)	.38 (.91)	.65 (.99)
Biphone Probability	-.13 (1.01)	-.25 (1.00)	.16 (1.07)
Age of Acquisition	-.32 (.66)	-.17 (.79)	-.11 (.89)
Word Frequency	2.81 (.70)	2.66 (.82)	3.21 (.86)

Note. IPP = Individual phoneme probability.

Table 3.

Odds ratios of child and item-level predictors for Sample 1 with blending and elision stimulus words

	Model 1	Model 2	Model 3	Model 4	Model 5	DFs
Intercept	.88	.89	.95	.93	.93	
PND	1.01	1.06	1.06	1.06	1.05	24
IPP	1.46	1.67*	1.58	1.58	1.57	24
BP	1.21	1.10				24
AoA	.38***	.41***	.41**	.41**	.40**	24
WF	.68	.58**	.49**	.49**	.49**	24
Item Type	.57*		.67	.67	.67*	24
Type X IPP			1.03	1.03	1.03	24
Type X AoA			1.06	1.06	1.02	24
Type X WF			1.37	1.37	1.37	24
CA	1.73***			1.54***	1.56***	381
OL	2.12***			1.96***	2.01***	381
CA X IPP					.97	13671
CA X AOA					1.02	13671
CA X WF					1.01	13671
OL X IPP					1.00	13671
OL X AoA					1.10**	13671
OL X WF					.92**	13671

Note. PND = phonological neighborhood density; IPP = individual phoneme probability; BP = biphone probability; AoA = age of acquisition; WF = word frequency; CA = chronological age; OL = oral language; DFs = degrees of freedom.

* $p < .05$; ** $p < .01$; *** $p < .001$.

$N = 392$.

Table 4.

Odds ratios of child and item-level predictors for Sample 1 with blending and elision target words

	Model 1	Model 2	Model 3	Model 4	Model 5	DFs
Intercept	.84	.85	.80	.78	.78	
PND	.81	.84	.88	.88	.88	25
IPP	1.19	1.74**	1.78*	1.78*	1.79*	25
BP	.97	1.13	1.08	1.08	1.08	25
AoA	.43***	.34***	.35***	.35***	.35***	25
WF	.61*	.43***	.40***	.40***	.40***	25
Item Type	.55**		1.10	1.10	1.09	25
Type X IPP			1.09	1.09	1.10	25
Type X AoA			.93	.93	.90	25
Type X WF			1.16	1.16	1.15	25
CA	1.73***			1.53***	1.54***	380
OL	2.12***			1.96***	1.98***	380
CA X IPP					.99	14450
CA X AOA					1.01	14450
CA X WF					1.11***	14450
OL X IPP					.97	14450
OL X AoA					1.11**	14450
OL X WF					.99	14450

Note. PND = phonological neighborhood density; IPP = individual phoneme probability; BP = biphone probability; AoA = age of acquisition; WF = word frequency; CA = chronological age; OL = oral language; DFs = degrees of freedom.

* $p < .05$; ** $p < .01$; *** $p < .001$.

$N = 392$.

Table 5.

Odds ratios of child and item-level predictors for Sample 2 with blending and elision stimulus words

	Model 1	Model 2	Model 3	Model 4	Model 5	DFs
Intercept	.83	.84	.89	.88	.88	
PND	.98	1.01	1.01	1.01	1.00	23
IPP	1.51	1.78*	1.77	1.77	1.77	23
BP	1.23	1.25				23
AoA	.35**	.38**	.37**	.36**	.36**	23
WF	.66	.56*	.45**	.45**	.45**	23
Item Type	.55*		.68	.68	.68	23
Type X IPP			.93	.93	.93	23
Type X AoA			1.06	1.06	1.04	23
Type X WF			1.54	1.54	1.54	23
IQ	1.05			1.06	1.06	802
CA	1.47***			1.52***	1.53***	802
OL	1.33***			1.38***	1.39***	802
CA X IPP					.98	28396
CA X AOA					1.06*	28396
CA X WF					.97	28396
OL X IPP					.99	28396
OL X AoA					1.04	28396
OL X WF					.98	28396

Note. PND = phonological neighborhood density; IPP = individual phoneme probability; BP = biphone probability; AoA = age of acquisition; WF = word frequency; CA = chronological age; OL = oral language; DFs = degrees of freedom.

* $p < .05$; ** $p < .01$; *** $p < .001$.

$N = 814$.

Table 6.

Odds ratios of child and item-level predictors for Sample 2 with blending and elision target words

	Model 1	Model 2	Model 3	Model 4	Model 5	DFs
Intercept	.78	.79	.75	.74	.74	
PND	.78	.82	.84	.84	.84	24
IPP	1.22	1.89**	2.08**	2.08**	2.08**	24
BP	.96	1.16	1.08	1.08	1.08	24
AoA	.40**	.31***	.30***	.30***	.30***	24
WF	.55*	.38***	.32***	.32***	.32***	24
Item Type	.53*		1.24	1.24	1.24	24
Type X IPP			1.03	1.03	1.04	24
Type X AoA			.90	.90	.88	24
Type X WF			1.15	1.15	1.15	24
IQ	1.05			1.06	1.06	801
CA	1.48***			1.52***	1.54***	801
OL	1.32***			1.38***	1.38***	801
CA X IPP					.97	30015
CA X AOA					1.06*	30015
CA X WF					1.02	30015
OL X IPP					.98	30015
OL X AoA					1.03	30015
OL X WF					.98	30015

Note. PND = phonological neighborhood density; IPP = individual phoneme probability; BP = biphone probability; AoA = age of acquisition; WF = word frequency; CA = chronological age; OL = oral language; DFs = degrees of freedom.

* $p < .05$; ** $p < .01$; *** $p < .001$.

$N = 814$.

Figure 1. Probabilities of correctly responding to early and late acquired phonological awareness items at high and low levels of oral language skills for children in Sample 1 with blending and elision stimulus words.

Figure 2. Probabilities of correctly responding to low and high frequency phonological awareness items at high and low levels of oral language skills for children in Sample 1 with blending and elision stimulus words.

Figure 3. Probabilities of correctly responding to low and high frequency phonological awareness items at high and low levels of chronological age for children in Sample 1 with blending and elision target words.

Figure 4. Probabilities of children correctly responding to early and late acquired phonological awareness items at high and low levels of oral language skills for children in Sample 1 with blending and elision target words.

Figure 5. Probabilities of correctly responding to early and late acquired phonological awareness items at high and low levels of chronological age for children in Sample 2 with blending and elision stimulus words.

Figure 6. Probabilities of correctly responding to early and late acquired phonological awareness items at high and low levels of chronological age for children in Sample 2 with blending and elision target words.

COPY OF IRB APPROVAL FORM

RE-APPROVAL MEMORANDUM

Date: 11/14/2011

To: Christopher Lonigan

Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research
Evaluating the Effectiveness of Preschool Literacy Curriculum: Follow-up

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 11/7/2012, you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc:
HSC No. 2011.7243

COPY OF INFORMED CONSENT FORM

Informed Consent Form

Title: **EVALUATING THE EFFECTIVENESS OF PRESCHOOL LITERACY CURRICULUM: FOLLOW-UP**

Investigator: **CHRISTOPHER J. LONIGAN, PH.D.**

The purpose of the research project in which we are asking you to participate is to learn how children's preschool experiences affect their later academic performance and later educational placements, including participation in Exceptional Student Education. All participants in this project were previously a part of our study on preschool curriculum that was conducted in collaboration with the local school district.

If you decide to participate in this phase of the project, your part in the project will only include consenting to allow us to review of some your child's school records. Neither you, nor your child, would be subject to any questionnaires, interviews, surveys, or assessments.

For this project, we would contact your child's school district and request that they provide us with information concerning your child's eligibility for prekindergarten in Leon County Schools or Taylor County Schools during the 2003-2004 or the 2004-2005 school year (i.e. school readiness program or Exceptional Student Education program). In addition, we will contact your child's current school district and request that they provide us with information concerning your child's current eligibility, if any, in Exceptional Student Education, along with his or her Stanford Achievement Test scores during their 2nd grade year, if applicable.

This information would be combined with the information that we have previously collected concerning your child's academic skill development (i.e., early reading, early math, and language skills) to allow us to determine how different experiences during preschool affect longer term educational outcomes.

Your participation may result in the following benefits:

The information that we gather from this project will be used to help understand how children's early experiences in preschool are related to reading development and future special educational placements. This information may be used to design intervention programs for children who are lagging behind in the development of their literacy skills and to help educators' better match curriculum to child abilities and development. This information from this project may help schools understand how to identify children who most need additional services. These children could be started on Academic Improvement Plans or begin remediation or intervention immediately upon entering Kindergarten. Additionally, it is possible that information gained from this study about the different preschool curricula from the project could help school districts in making decisions about curriculum, methodology for prekindergarten or later intervention strategies, or both. All of these efforts could lead to improved outcomes for children.

We know of no risks associated with you or your child's participation in this project.

Your and your child's participation is voluntary. You do not have to participate if you do not want to. Your decision whether to participate or not will have no effects on any other treatment or services to which you are entitled from Florida State University or any institution associated with the project. You may change your mind and withdraw from this project at any time without penalty. There are no risks associated with withdrawal from this project.

All information obtained as a result of this project will be kept confidential, to the extent allowed by law. Confidentiality will be ensured in the following ways: In public reports of the results of this project, we will only report results that have been averaged over large numbers of children. No individual child or family will ever be identified publicly. The information collected will be used solely for research purposes. Any assessment or other information gathered on your child will be kept in a locked file storage area in research offices at the Florida Center for Reading Research (Department of Psychology) at Florida State University, identified only by a code, and it will not be available to any other person or institution unless you ask us in writing to make it available. Identifying information will be retained for a period of up to 2 years following completion of this project. It is expected that the project will end by 06/01/12. Data from this project, with all identifying information removed, will be retained indefinitely.

If at any time you have questions about this project, please contact Dr. Christopher Lonigan at the Department of Psychology, Florida State University. A description of the group results of this project will be sent to you upon request. If you have questions about your rights as a participant in this project, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Office of the Vice President for Research, at (850) 644-8633.

If you agree to participate in this research project, please sign and print your name and the name of your child below. Your signature indicates that you have read the information provided above, or have had it read to you, and that you have decided to participate. A copy of this consent form has been offered to you.

Signature and printed name of parent or legal guardian

Today's Date

Printed name of child Child's

Date of Birth

Name of school that your child currently attends

Please include the following information so that we can contact you regarding project results.

Street Address

City State Zip

Home Phone: _____ **Work Phone:** _____

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BIOGRAPHICAL SKETCH

J. Marc Goodrich was born on February 18th, 1987 in Austin, TX. He received a bachelor's degree in Psychology and Spanish from the University of Texas at Austin. He is currently a graduate student in Developmental Psychology at Florida State University and is supported by a Predoctoral Interdisciplinary Research Training Fellowship.